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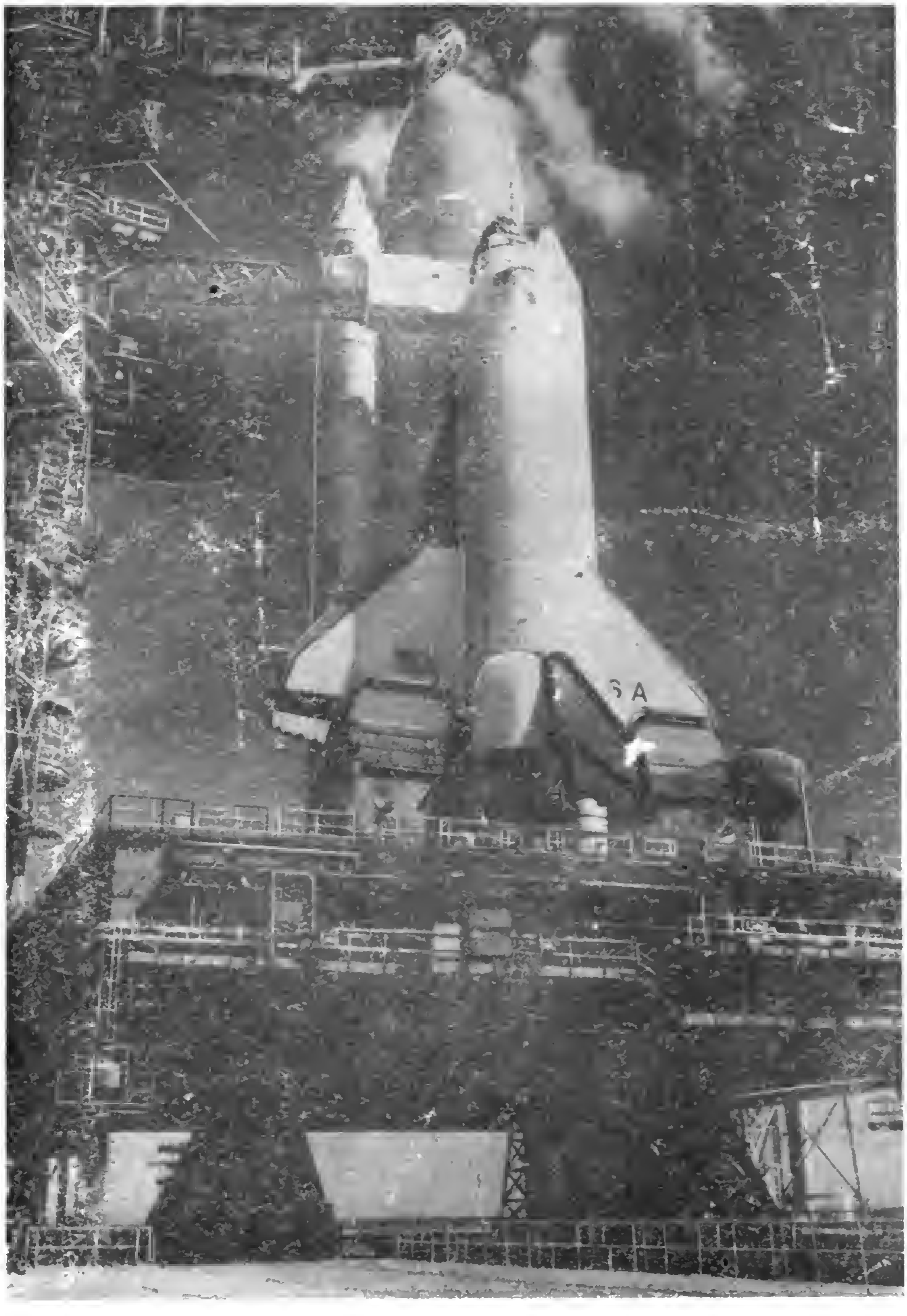

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SPACEFLIGHT

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CONTENTS

2 **Transportation For Solar Power Satellites** *Raefe M. Shelton*

7 **Off To The Asteroids** *Andrew A. Thomson*

14 **Space Report**

20 **The Spacelab 2 & 3 Missions**

23 **News From The Cape** *Gordon L. Harris*

24 **The Solar Mesosphere Explorer** *Andrew Wilson*

26 **Space Communications**

28 **Salyut 6 Mission Report: Part 9** *Neville Kidger*

30 **The Cosmonauts: Part 22** *Gordon R. Hooper*

32 **Satellite Digest - 150** *Robert D. Christy*

34 **The NOAA Environmental Satellites** *Nicholas Steggall*

41 **Book Reviews**

44 **Correspondence**

COVER

READY ONCE MORE. STS-2 is poised to take Orbiter *Columbia* into orbit for the second time. This is the first occasion that a manned spacecraft has made two trips into space (the Gemini 2 capsule did it in unmanned configuration in the 1960's).

NASA

MILESTONES

August 1981

26 Voyager 2 flies past Saturn in its close encounter. Despite a jammed instrument platform for some of the fly-by, Voyager sends back images of the rings to show that they are even more complex than scientists believed after Voyager 1.

31 Shuttle *Columbia* is rolled out to the launch pad for an October 9 lift-off. An accumulation of small delays led to the later launch date.

September 1981

5 Soviet sources report that an Indian will be trained as a cosmonaut for a future space mission. According to the pattern set by previous foreign cosmonauts two men will go through the training, with one finally acting as back-up.

21 Soviet booster takes the French Arcad 3 satellite into orbit. The 2200 lb craft will collect data on the magnetosphere at high latitudes over a planned 6 month lifetime.

22 A leak of nitrogen tetroxide during filling operations of *Columbia's* reaction control system damages about 380 tiles, causing some of them to fall off. A faulty seal allowed the corrosive fluid to splash into the nose bay, where much of it was absorbed by thermal blankets, and down the starboard tiles. Most of the tiles are thought to be reusable and the repairs will be carried out on the pad. The 9 October launch date may now slip by over a month.

24 SBS-2, a communications satellite to serve US domestic business needs, is launched by a Delta-PAM combination. It will eventually be located at 97 deg. west longitude. This is the second PAM upper stage launch - the first, with SBS-1 in November 1980, was successful but a ground test failure delayed subsequent use.

26 It is reported that Soviets scientists have proposed that the F-ring of Saturn is, in fact, a small orbiting black hole. Other ringed planets may also have black holes.

29 Salyut 6 completes its fourth year of operation in space. At present it is docked with Cosmos 1267.

October 1981

5 The External Tank for STS-3 (ET-3) arrives at the Kennedy Space Center by barge, and is taken to the Vertical Assembly Building for processing. This will be the first Tank to be flown (STS-3 launch date is scheduled for mid-March) without an outer covering of white paint, thus saving over 500 lb in weight. Later Tanks will be even lighter.

В журнале не печатается ряд страниц.

MEMBER SERVICES

Sweatshirts	*p. 37*	New-Style Society Ties	*p. 38*
T-Shirts	*p. 37*	Meeting Notices	*back cover*
Subscription Fees	*p. 31*	Library Opening Times	*back cover*

TRANSPORTATION FOR SOLAR POWER SATELLITES

By Racfe M. Shelton*

Introduction

The Solar Power Satellite concept is the largest application of Large Space Structures currently under detailed consideration (if we exclude some of Prof. O'Neill's Space Colonies). Much has been written and spoken about the concept in the last few years, so that a detailed description is not appropriate here; suffice it to say that the concept involves interception of Solar Radiation in the location where it is both constant and unattenuated by the atmosphere (i.e., in Earth orbit); conversion into electricity, probably by Photovoltaic devices; further conversion into a form suitable for energy transmission to the Earth's surface, currently either microwave or laser energy; and finally reception on the surface and reconversion into electrical energy to feed into the National Grid.

Cost/benefit trade-off studies, coupled with power density limitations imposed by safety and environmental considerations, which were conducted in the early days of concept evaluation centred on satellites supplying some 5GW *via* a 1km diameter microwave transmitting antenna. Using current or foreseeable photovoltaic efficiencies, such a satellite would require an area of solar array some 10km by 5km.

The Solar Power Satellite concept has been under intensive study in the United States and several other countries for some 13 years, and to date all assessments have shown no reason why the concept should not be technically feasible, environmentally acceptable and economically a potential competitor as a major energy source for the next century.

In fact, the World Energy Conference held last year listed three major sources of energy for the mid-term (first half of 21st century). These were Nuclear Fission (the Fast Breeder Reactor), Nuclear Fusion, and the SPS Concept. Of these, Nuclear Fission is undergoing political and environmental opposition; Nuclear Fusion has yet to demonstrate technical feasibility and is not devoid of the same sort of environmental problems as Fission; while the SPS concept, while offering not inconsiderable technical and environmental problems of its own, is at least based on known or foreseeable technologies and is, comparatively at least, environmentally 'clean'.

Technically and economically, the major feature of the concept is the requirement to position in Earth orbit structures a thousand times as large and massive as anything attempted to date. It is, therefore, not surprising to find that space transport and construction together constitute a very large proportion of the cost estimates.

A further feature of the concept is the very high ratio of 'front-end' costs to production costs, in comparison with most terrestrial power systems (with the notable exception of Fusion). Of these 'front-end' or Total to First Unit (TFU) cost estimates, totalling some $101B, transport and construction constitute a massive 75%; these elements also contribute to 39% of the production cost of subsequent units (estimated at $12B) as shown in Fig. 1.

The Space Transport System (STS)

Studies of the SPS concept have emphasised that economical installation and operation of such a system would demand prior development of a 'mature' Space Transport System, whose characteristics are:

- All components fully re-usable.
- 'Airline-type' operations, i.e. minimum maintenance, rapid turn around with minimum fleet size, minimum operating cost.

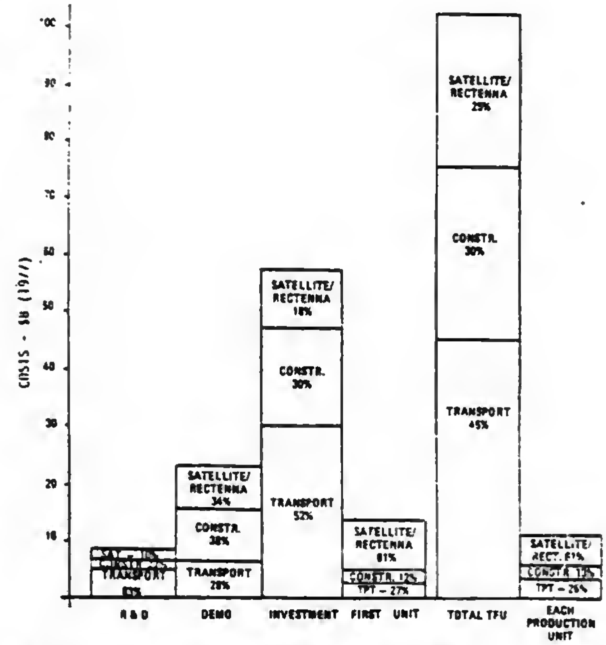

Fig. 1. Breakdown of estimated SPS costs (NASA).

- 'Custom-built', i.e. each component designed to match a specific major task.

US studies to date have concentrated on the major elements of a system to meet these criteria and have identified four such elements [1]:

- Launch of freight into Low Earth Orbit (LEO)

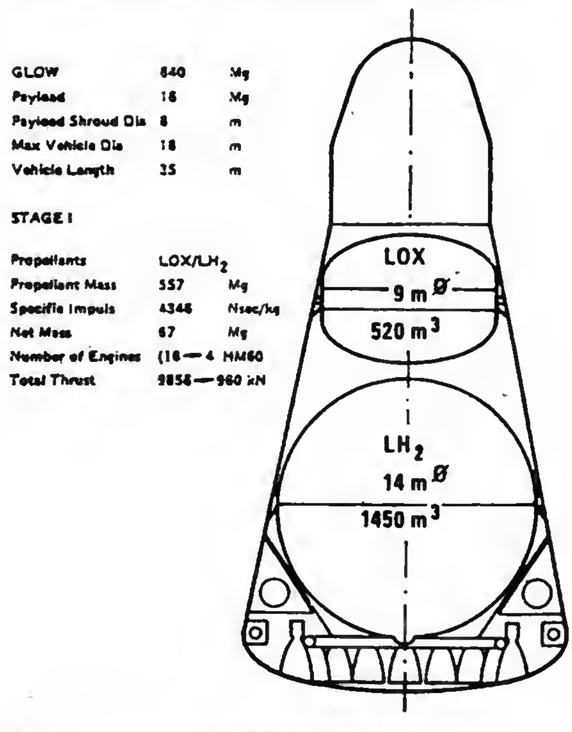

Fig. 2. RLV-5: unmanned ballistic reusable SSTO.

* *British Aerospace Dynamics Group, Bristol Division.*

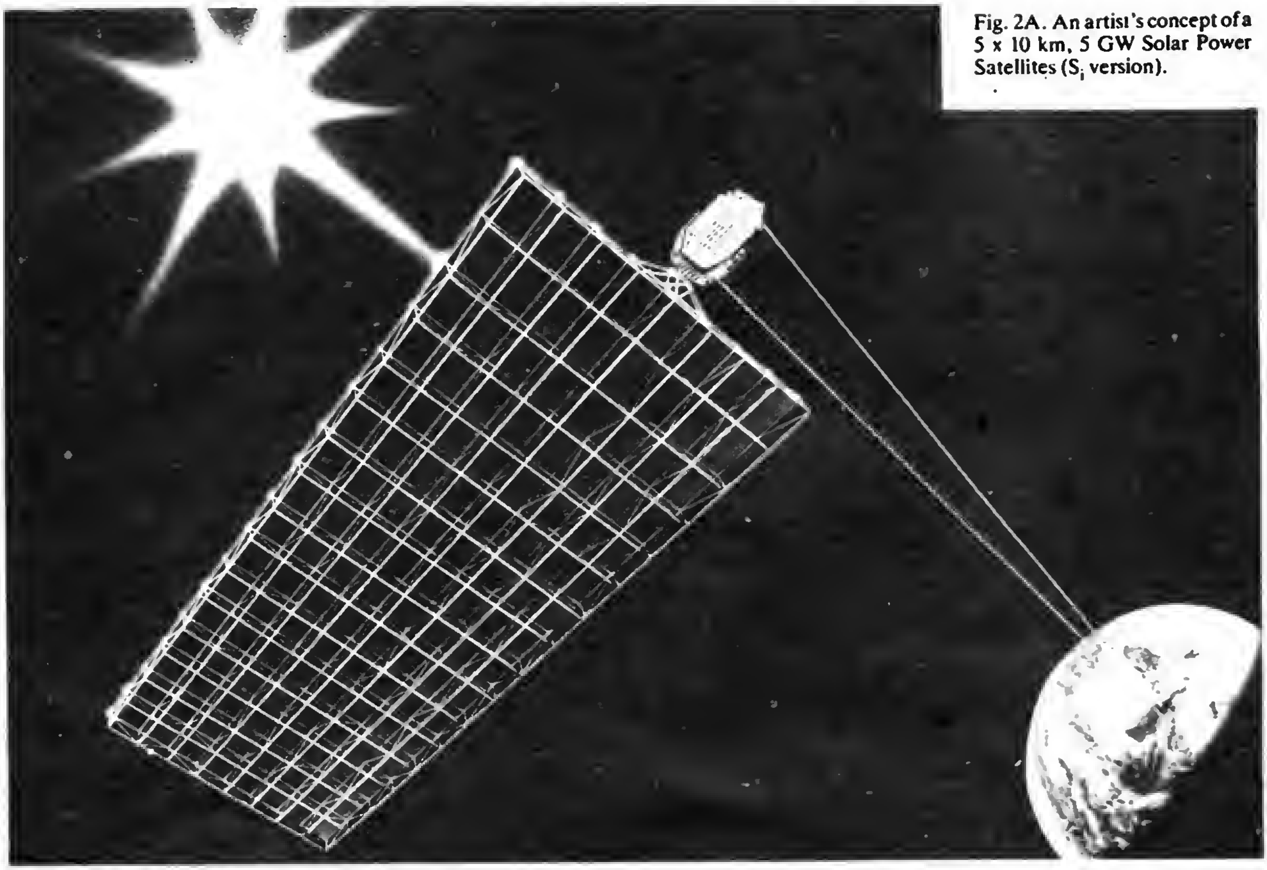

Fig. 2A. An artist's concept of a 5 x 10 km, 5 GW Solar Power Satellites (S_i version).

- Launch of personnel into Low Earth Orbit (LEO)
- Transfer of freight from LEO to Geosynchronous Orbit (GEO)
- Transfer of personnel from LEO to Geosynchronous Orbit (GEO)

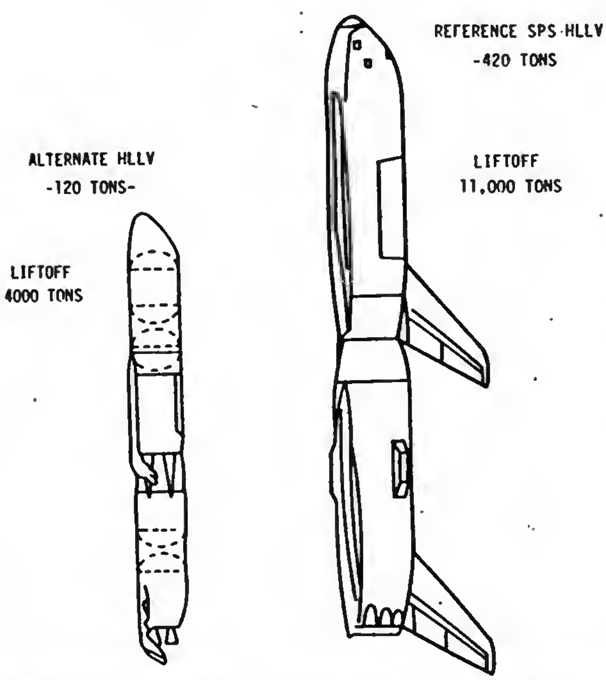

Fig. 3A. Boeing (NASA Reference) HLLV and alternative launcher.

Heavy Lift Launch Vehicle (HLLV)

Of these elements the most critical is the first, the freight launcher or HLLV, which is, by its very nature, not only the most demanding but also the most expensive, constituting over 70% of the transport cost of each production unit and a large part of the STS development and investment cost.

In the SPS Reference System, published by NASA as a basis for technology assessments [1, 3], and for the Environmental, Societal and Comparative Studies the HLLV is based upon development of the Shuttle concept — i.e. it is a manned, staged and winged vehicle for aerodynamic return to the launch point. The HLLV has two stages, both winged and fully re-usable and a payload of some 420 tonnes.

Studies by D. Koelle of MBB [4] have argued that for a freight vehicle, wings and a human crew are unnecessary and wasteful; an un-manned ballistic re-usable vehicle would be more cost effective. However, such a vehicle would have less cross-range capability and hence less operational flexibility; and though development costs could be less operational costs are likely to be higher.

Such large vehicles, with payloads between 300 and 500 (or even up to 700) tonnes, would be SPS-specific. Recent studies [2, 3] suggest that a vehicle with a payload of around 120 tonnes would be more versatile in its potential applications and much easier and cheaper to develop. Assessments [3, 7] show a reduction in STS development costs of about $5,000M — approximately 11%, and about 5% of total SPS TFU costs. The resulting increase in operational (recurring) costs is assessed at $900M — about 33% of the transport cost, but only 8% of the total cost of each operational SPS. The argument is that development of this smaller vehicle would increase the overall cost of an SPS system in the long term (past the first 50 stations), but would reduce 'front-end' costs in the short term, and possibly allow these costs to be spread across more than one project.

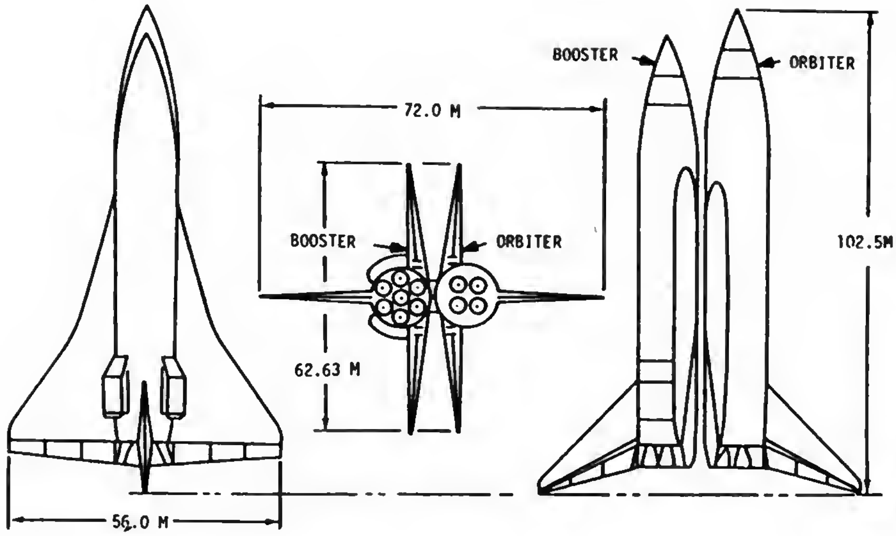

Fig. 3B. Rockwell Heavy Lift Launch Vehicle.

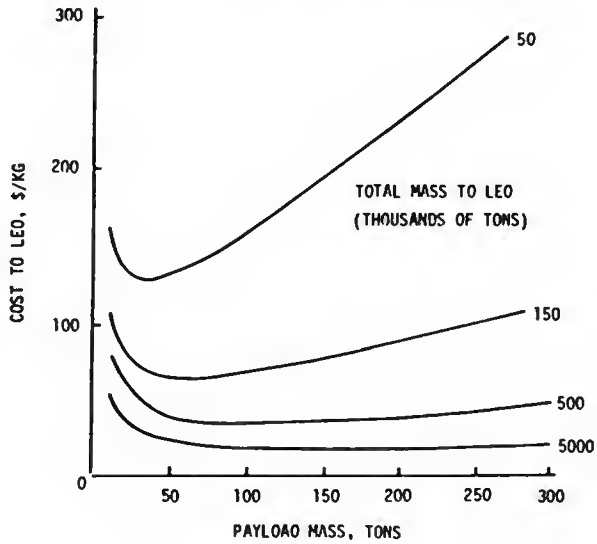

Fig 4 (below). Cost of payload mass to Low Earth Orbit for completely reusable space transport with fixed demand.

It is also interesting to note that a Study by Prof. Miller and some of his Research Assistants at MIT [5] found that for a Space Transport System with a limited overall demand the optimum vehicle payload is between 30 and 70 tons. Even if demand is unlimited, there is little benefit in increasing payload beyond this range.

Personnel Launch Vehicle (PLV)

The Reference vehicle for transport of personnel to LEO is a direct Shuttle derivative with a 70 seat passenger module in the cargo bay and fully reusable boost stages.

It has been argued [7] that separate development of such a vehicle would not be cost-effective if only the SPS project is taken into account, and that it would be preferable to add a personnel module aboard the HLLV, providing safety margins were adequate. The NASA cost estimates for the PLV show development of a re-usable booster costing more ($2,600M) than total subsequent hardware procurement for a 60-SPS programme ($1,900M). On the other hand, such a

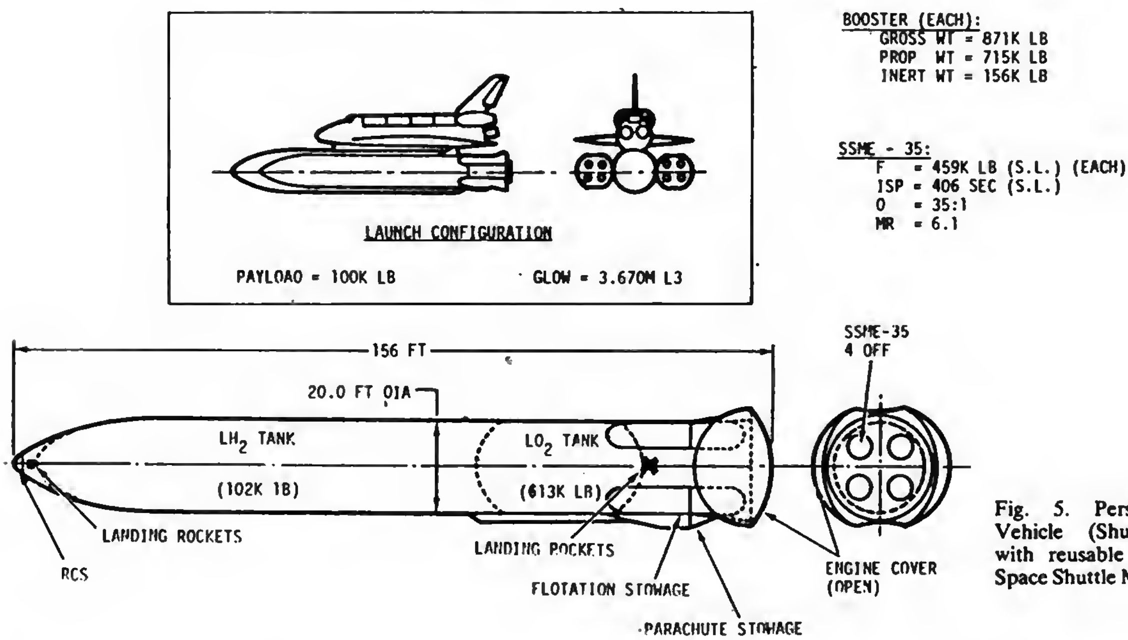

Fig. 5. Personnel Launch Vehicle (Shuttle derivative with reusable boosters using Space Shuttle Main Engines).

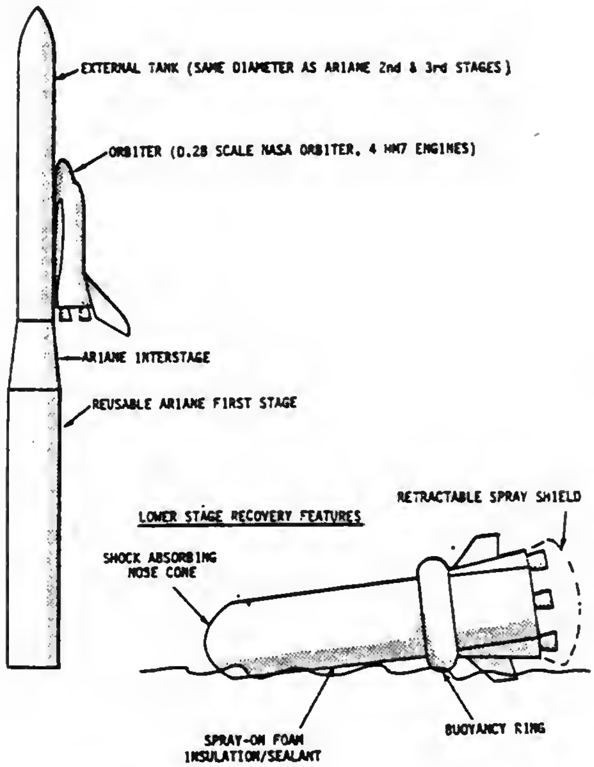

Fig. 6. The Spacecab concept.

development is a natural extension of current Shuttle capability and is likely to be justified by an overall space transport requirement for a light-cargo/personnel vehicle for a multiplicity of missions and projects. In this case, however, the development cost would not be chargeable exclusively to SPS.

In this context, it is also likely that an overall scenario of expansion into space will show a requirement for an even smaller, quick response, general purpose vehicle for transport or urgent freight and personnel: a 'Space taxi'. Development of such a vehicle, starting from existing expertise derived from Ariane, Shuttle and high-speed aircraft experience, could be ideally suited to European entry into manned spaceflight. Current proposals include 'Hermes' and 'Spacecab'. The former is dependent upon Ariane for launch but offers an aerodynamic return capability; the latter, while looking to Ariane technology and launch in its development phase, offers independent Earth-to-orbit operations which could be significantly more flexible and cost-effective [9, 10].

Orbital Transfer Vehicle (OTV)

For the orbital transfer mission from LEO to GEO, the parameters are quite different. Delta-V requirements are less than for the Surface-to-LEO stage but the much greater distance means that trip time becomes a significant factor and, in particular, transit time through the Van Allen trapped-radiation belts.

For personnel and radiation-sensitive cargo, high-thrust propulsion is essential to reduce trip time to a minimum; at present such propulsion can be provided only by chemical rockets, although in the future a form of nuclear-thermal propulsion may offer advantages in terms of increased specific impulse and, hence, less reaction mass (fuel) required to be transported into space.

A chemical OTV can be optimised for use only in space and current designs look similar to Space Tug and rely on NASA's Advanced Space Engine [1, 2, 3, 6].

As far as opportunities for European participation are concerned, most of the same comments apply as for the Earth-to-LEO vehicles.

Construction Options

The requirements for freight, transport from LEO to GEO depend upon the chosen construction method and location. Three basic options exist:

- Complete construction in LEO, transfer of complete station from LEO to GEO.
- Partial construction in LEO, transfer of sections to GEO followed by final assembly and commissioning.
- Transport of all components to GEO, with construction and commissioning in final location.

The first option is most economical in transport and construction costs, and reduces requirements for crew radiation shielding, etc., but has the severe disadvantage that the much higher gravity gradient forces in LEO would require an SPS structure 200 times as strong (and hence massive) as necessary in operation. Also, a very large quantity of Attitude Control propellant would be required during the orbit transfer and the quantity of uncharted debris in LEO introduces a significant chance of damage to such a large structure.

The second option is attractive since the bulk of construction activities remain in the lower orbit, while the individual SPS sections would undergo transfer more easily and safely. However, restoration and repair of damage (particularly to solar cells) caused by passage through the Van Allen belts would still be required. It is anticipated that such damage could be greatly reduced by the use of Gallium Aluminium Arsenide cells with solar concentrators, since at an elevated working temperature such cells are expected to be self annealing.

The third option entails siting only a staging base in LEO, with transfer of packaged materials and components to GEO aboard a specialised Cargo OTV, with all construction activities taking place in the final location. This was the option selected in NASA's Reference SPS System.

Development Steps

A system such as SPS will not appear complete and fully-fledged, but will be the end product of a lengthy and careful development programme. It may be of benefit therefore to consider the transport requirements of such a programme, which will also constitute the development of the full mature transport system outlined above.

The twin keys to this development are space construction, and (in NASA's view at least) manned operations in space.

For the US, the course of development is obviously *via* full exploitation of the Space Shuttle, developed for long-duration orbital operation and full re-usability. Initial activity may employ deployable structures, then experimentation with space construction, either assembling structural components lifted from the surface or employing beam-building machines like those already being developed by Grumman. This would perhaps be followed by the Space Operations Center, a permanently manned orbiting station specifically designed for construction and space applications, and thence to large applications platforms. Each step would be accompanied by parallel developments in space generation of power.

Development of the Space Shuttle would meet the Earth-to-LEO transport requirements until the latter stages, when a larger derivative of perhaps 100-120T payload capability would become necessary.

LEO-GEO orbit transfer is likely initially to be provided by

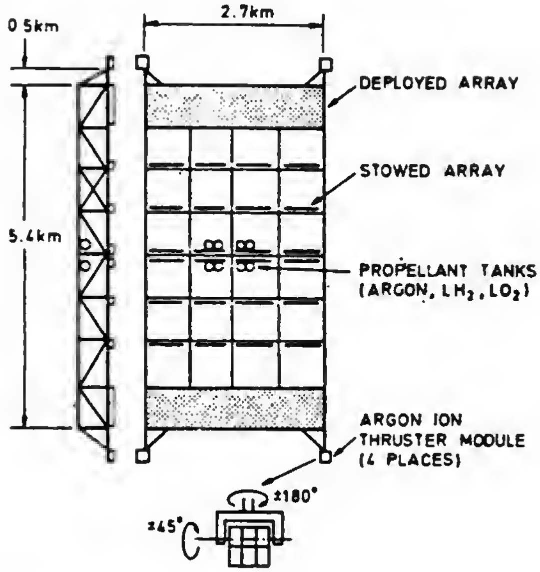

Fig. 7. Self-propelled SPS segment.

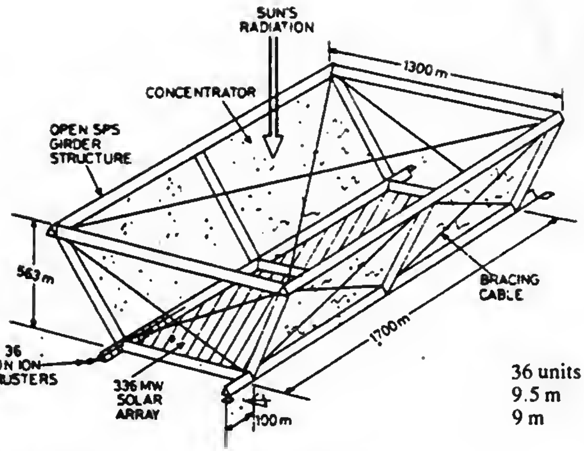

Fig. 8. Electric Orbital Transfer Vehicle.

chemical boosters of the IUS/Centaur type, though Solar Electric Propulsion is greatly to be preferred where transit time is not important (unmanned payloads) because of the enormously-increased specific impulse available, and hence economy in fuel and cost.

European Development

European entry into these vital keys to the next stage of development in space can be provided by Spacelab and its Pallets developed as free-flying modules. Initial launch would, of course, be dependent on co-operation with the US and the availability of Shuttle launches, but subsequent servicing could be provided by independent European development. Ariane could provide reasonably economic large-scale freight transport, if coupled with development of automatic docking techniques, while the Spacecab concept outlined earlier would provide facilities for transporting crew and urgent supplies. In addition, development of automatic deployment or construction of space structures as Ariane payloads would provide a parallel approach, at least in the initial stages. Manned operations, however, must provide the necessary flexibility for long-term and large-scale Space operations.

Also, economical use of Ariane in such a long-term development programme must depend on development of re-usability, at least of the first stage and later of upper stages as well.

For placement of payloads in GEO, Ariane again offers an immediate but somewhat limited capability; in the mid- to long-term, again, only Solar Electric Propulsion offers the necessary economy of operation for a true mature system.

Conclusions

The principal obstacle to large-scale exploitation of the space environment is the cost and practical difficulty of transporting payloads up through the steepest portion of the Earth's gravity well. Overcoming this obstacle depends on development of a 'mature' space transportation system whose characteristics are similar to those of the Air Transport System developed to exploit that environment.

This paper has described the proposed Space Transport System developed in the course of the US D. of E./NASA SPS Concept Development and Evaluation Program, but has also attempted to show that such a system will not be developed 'ab initio', but will grow from present technology; and that the bases for such development exist now both in the US and Europe. If Europe does not wish to be left behind in the exploitation of this last major frontier, the Industrialisation of Space, then it must enter wholeheartedly into utilisation and development of the not inconsiderable resources it already possesses.

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OFF TO THE ASTEROIDS

By Andrew A. Thomson

David A. Hardy

Introduction

Europe's most consisitently successful steps in space to date have been in the field of space science. Before the European Space Agency was formed in 1975, the European Space Research Organisation (ESRO, formed in 1964) brought together the scientists and industrial teams to design, build and use an impressive variety of Earth-orbiting science satellites. Twelve have been launched to date, covering studies of the ionosphere, Earth's geomagnetic field, Sun-Earth relations as a whole, and X-ray, Gamma-Ray and Ultra-Violet astronomy.

Since the establishment of ESA much attention has (rightly) gone to applications projects - such as the Meteosat weather satellites, the Orbital Test Satellite communications satellite - but the science programme remains near the heart of the European space effort. Although now accounting for only some 15% of ESA's budget it is the only activity in which all Members are obliged to participate. New projects are selected by the Science Programme Committee. Last year 'Hipparcos', an astrometry satellite (to measure the position and motion of 100,000 selected stars), was selected from a list of five candidates.

Four proposals were the subjects for assessment studies in the first half of 1981: Magellan (an astronomical satellite for ultra-violet spectrography), Kepler (a Mars geophysical orbiter for studying the Martian atmosphere, ionosphere and magnetic fields), Disco (Dual Spectral Irradiance and Solar Constant Orbiter, a solar observatory) and Asterex (an asteroid probe). Magellan and Kepler will now undergo a Phase A study and be put forward for selection in late 1982/early 1983, and Disco will be studied further.

Asterex, even though it has lost out to the other proposals, will surely be flown someday, *albeit* in an altered form. The Americans have always been interested in their own version

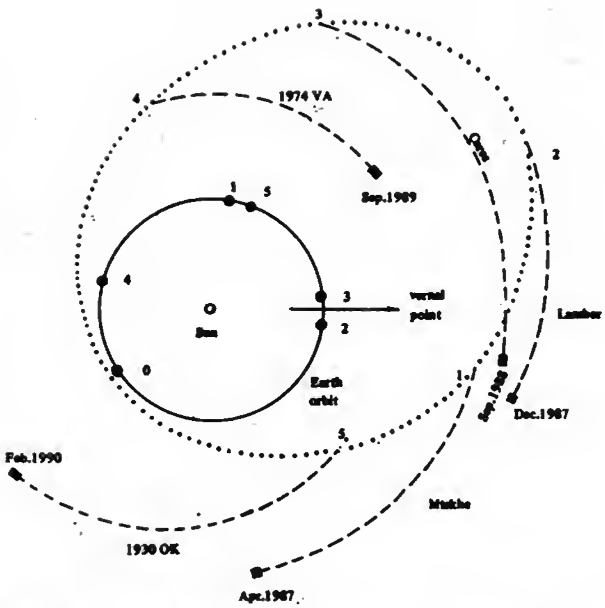

Fig. 1. A possible asteroid probe trajectory with launch on 15 April 1987, and the first encounter on 12 December 1987. The final flyby, on 25 November 1990, is with asteroid 1930 "ok". The single numerals show the positions of the Earth and probe at each encounter, while the dates on the asteroids refer to their positions at the previous encounter (or launch in the case of Mtskhe).

An asteroid probe has not received approval for further ESA study but such a mission will undoubtedly be undertaken someday.

ESA

but it fell by the wayside when development work on electric thrusters was cancelled.

The Asteroids

Asterex would take a small unmanned probe on a reconnaisance mission to fly-by three or more asteroids. The asteroids are the minor planets which circle the Sun, most of them in a belt between the orbits of Mars and Jupiter. They mark the divide between the inner solid planets (Mercury, Venus, Earth and Mars) and the outer gaseous giants (Jupiter, Saturn, Uranus and Neptune). First discovered in 1801, some 2000 of these small rocky bodies have been discovered to date; it is thought there may be between 40,000 and 100,000 in total. They vary enormously in size and shape - only ten have diameters greater than 100 miles, many hundreds are only a few miles across. It is thought that if all of the asteroids were brought together they would form a body one-thousandth the size of Earth. Some asteroids have orbits highly inclined to the plane of the ecliptic (the plane in which most bodies of the Solar System orbit the Sun); some have very eccentric orbits - to quote an extreme, that of 'Icarus' brings it well inside the orbit of Mercury at perihelion (closest approach to the Sun) but out to the main Asteroid Belt at aphelion (furthest distance from the Sun).

The main Belt forms a doughnut-shaped region some 150 million miles wide, with the asteroids in the centre orbiting the Sun at approximately 38,000 miles per hour. One should not picture the asteroids as "filling" the Belt: they are so spread out as to rarely come within half a million miles of each other. The Pioneer 10 and 11 and Voyager 1 and 2 spacecraft on their way to Jupiter and Saturn passed through the Belt unscathed. Asteroids have been mentioned as potential sources of raw materials for future space utilisation. There is even talk of using a small asteroid as the basis of a 'space ark' to travel to the stars.

We know very little about the asteroids - little more than outlined above. Despite the great progress in Solar System exploration in the last two decades, they remain just point sources of light. In the last ten years the study of asteroids has progressed from that of simple optical observation to include studies of their spectra. However, Earth-based study has nearly reached its limits: with such tiny and distant bodies there is little more to be discovered from Earth.

An asteroid reconnaisance mission will provide us with our first close view, our first chance to see what they look like, to find out more than just their orbital parameters or the hint we get from spectroscopy as to their composition. To date there have been surprises at many stages of our exploration of the Solar System - the giant Martian rift valleys for instance, or the rings of Jupiter and the active volcanos on its moon Io. Who knows what we might see in the Asteroid Belt?

Scientific interest

Most asteroids are of special interest as possible witnesses of the very early stages of the evolution of the Solar System. Some of them are probably remnants of planetisimals (small bodies) similar to those from which the planets accreted, according to one theory of Solar System evolution. Being so small, the asteroids have probably escaped the thermal and chemical alteration undergone by planets and many satellites; consequently they can be expected to contain much chemically primitive material characteristic of the original bodies produced when the nebula of gases surrounding the primitive Sun first condensed. This condensation is the first stage in a widely accepted theory of planetary evolution; the second stage is the accretion of thousands of the resulting 'planetisimals' into planets. The most commonly used image to describe this is that of embryo planets 'sweeping up' particles and minor bodies as they swing around the Sun, combining into one large body. It is thought that the asteroids did not accrete into a planet possibly because of some effect of the presence of the giant Jupiter - Asterex could provide clues as to how exactly this might have operated.

Asteroids are also important as true planetary bodies: their surface features as well as their internal structure are mostly unknown. We may expect that a close approach will reveal as much as the close observation of the the satellites of Jupiter, of the two Martian satellites Phobos and Deimos, or of the satellites and ring system of Saturn. These small objects are

Fig. 2. Mounting evidence indicates that Phoebe, Saturn's outermost known satellite, is almost certainly a captured asteroid and did not form in the original Saturn nebula as did the other satellites. Voyager 2's observations of Phoebe on 4 September 1981 showed that it is about 200 km in diameter - about twice as large as Earth-based observations had measured it to be. It is darker than any other of Saturn's known satellites, with about 5% reflectivity.

JPL

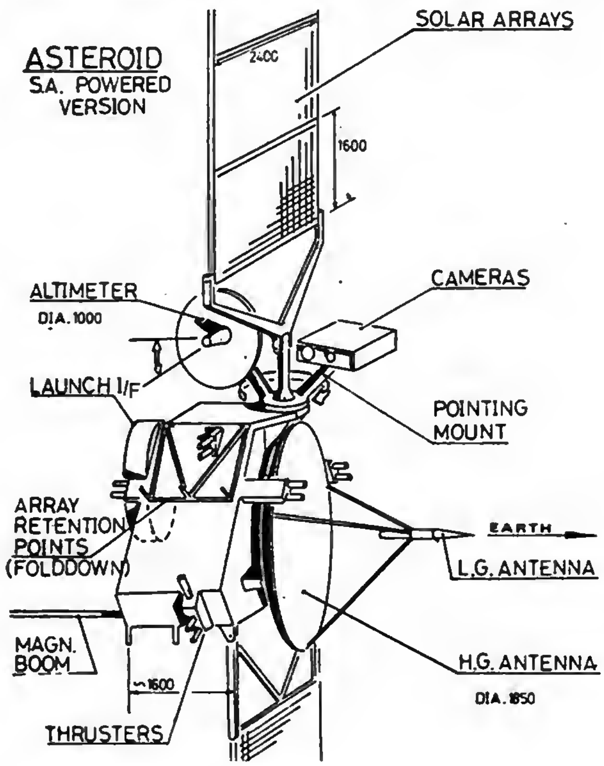

Fig. 3. A possible configuration for an asteroid probe, carrying solar arrays for power. Nuclear generators - similar to those used in the Pioneer and Voyager deep-space probes - are an alternative.

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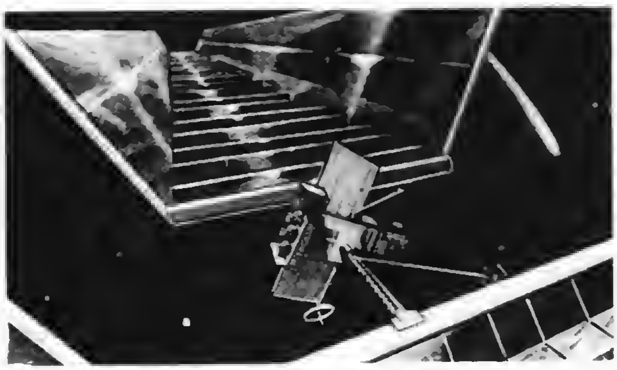


Fig. 4. Not an asteroid spacecraft, but an ion-propelled probe to Halley's comet as proposed by NASA. Work on such electric propulsion was halted but the concept remains attractive for long-duration deep-space probes. *NASA*

remarkably individual and seem to have been subject to processes which were totally unanticipated before high resolution images were obtained.

Among the questions to be answered about the asteroids are:

- Do asteroids represent various stages of accretional processes?
- What exactly are the relationships between asteroids and meteorites?
- How important a role have asteroidal bodies played in cratering the surface of planets and satellites?
- Do asteroids have undiscovered satellites?

The scientific output of the Asterex mission can be substantially strengthened by proper correlation with observations from Earth-orbiting platforms (eg. the Space Telescope to be orbited in 1985) as well as with further ground-based observations. Such future observations will be all the more valid with 'hard facts' on a handful of asteroids to build on. We will know if our extrapolations from the scant data we have had to date are right.

The most important properties of asteroids to be studied are:

1. cratering: the mechanics of high velocity impact cratering are not well understood. Both gravity effects and the mechanical characteristics of the target material seem to have a dominant influence on crater form and structure.

2. comparitive study of cratering on different asteroids will provide a unique means of testing the relative importance of these two effects (e.g. compare craters on asteroids of similar surface gravity but different surface properties).

3. surface geology: any lava flows, groove patterns or unusual features? Variations in texture and/or colour?

4. mineralogy: surface mineralogy can be obtained by studying the spectra of light reflectances on asteroids at certain wavelengths. Knowledge of minerals will greatly help our understanding of the relationship between asteroids and meteorites.

5. shape, size and spin.

Asterex's Scientific Instruments

Asterex has been kept as simple as possible and designed to carry three instruments:

1. an imaging camera (for optical images with a resolution of 30 metres at 1000 km distance)
2. an infrared spectrometer (to provide reflection spectra of each asteroid)
3. a radar altimeter (to measure distance between spacecraft and surface, and velocity of spacecraft relative to the asteroid).

Spacecraft design

Asterex weighs approximately 750 kg (1653 lb) and is 3-axis stabilised with a gyro-controlled platform with two degrees of freedom, carrying the scientific instruments and an asteroid sensor. Power is generated by a deployable 2-wing solar array, together with a battery of limited capacity. A bi-liquid propellant system provides the required velocity increments, while a cold gas system provides attitude control using information supplied by on-board Sun-sensors, a star-tracker and gyros.

Asterex will be a great distance from Earth at encounter - up to 400 million miles - and over 320 million miles from the Sun (3.5 Astronomical Units, ie. 3½ times the Earth-Sun distance). These figures show the ambitious nature of the desire to fly-by the targets at a separation distance of about 600 miles (1000 km). The craft is designed for a lifetime of three years, though the actual encounters will last only a little over one minute each. With radio signals taking up to 75 minutes for each roundtrip at those distances, actions during encounter will have to be fully automatic, findings being read back to Earth afterwards.

Flight Plan

Launch is by Ariane 4 (an uprated version of ESA's present Ariane I launcher) into a parking orbit around the Earth. After vehicle checks and navigational alignment a fouth-stage engine fires the probe out of Earth orbit into a ballistic trajectory that brings it to the Asteroid Belt after some eight months of flight.

Much work remains to be done on plotting trajectories to pass as many asteroids of interest as possible, and also to ensure that there are options to cover the several years when launch might actually occur.

Figure 1 shows an example of a trajectory with five fly-bys. the two solid lines show the orbit of the Earth and the elliptical orbit around the Sun that Asterex is inserted into. The numerals show the positions of Earth and Asterex at the five encounters, the dotted lines being the movement of the asteroids since the preceeding encounter (or in the case of the first asteroid, since launch). In this example, launch is on 15 April 1987, with first encounter - with the asteroid Mtskhe - on 12 December. Lamberis flown past nine months afterwards (13 September 1988), and Ceres - the first asteroid to be discovered - a further year on (16 September 1989). After fourth encounter - with asteroid number 1974VA on 23 February 1990 - Asterex returns to the vicinity of Earth's orbit round the Sun at the start of its second circuit of the Sun. Fifth and final encounter occurs with the asteroid 1930OK on 25 November 1990, over three years and seven months after launch.

Conclusion

Asterex is an exciting suggestion, one that if carried out will provide the European space community with an impressive "first" in Solar System exploration. We have a chance to execute an interplanetary space mission of great sophistication - demanding considerable skills in navigation, tracking, automation, adaptability to extended flight, and precision observation and recording by instruments during very brief fly-by periods. Asterex gives Europe the chance to perform such a mission to a largely unexplored part of the Solar System. For planetary science and for the maturity of the European space drive it is an excellent opportunity.

GALILEO . . . WORK CONTINUES

Components for the Galileo spacecraft, scheduled for a 1985 launch to Jupiter, are nearing completion, and the development model for the heat shield on the probe recently passed tests at the NASA Ames Research Center.

Galileo is a two spacecraft (orbiter and entry probe) mission to extend our knowledge about Jupiter and its moons.

The probe heat shield is only one of hundreds of components which are either now undergoing tests or will soon begin their test phase. Programme manager Ron McCullar says that approximately 95 percent of the flight parts have been delivered and the designs for the two spacecraft and the mission are nearing completion.

The Ames-designed probe heat shield, being built by General Electric, will encase the Jupiter probe instruments with two pieces. The first, a conical-shaped front shield made from a carbon cloth treated in plastic resin (carbon phenolic), will be 10 cm thick at the nose and up to 125 cm in diameter. The rear piece will be composed of a slightly different material, nylon phenolic, because this lower density material will save weight while still providing adequate protection for the less severe afterbody heating environment.

The probe, when it plunges into Jupiter's atmosphere, will be travelling at 48.2 km/s (115,000 mph), fast enough to cross the Atlantic in under two minutes. This entry speed will expose the probe to nearly seven times as much radiation as our Sun produces at its surface.

Upon entry, aerodynamic braking by Jupiter's thick atmosphere will decelerate the probe at 300 g!

During this extreme braking, the sacrificial front body shield will vaporise down to a mere 1 cm. The vaporisation of the carbon phenolic material will provide a heat-absorbing blanket to protect the seven probe instruments until a parachute opens and yanks the remaining shields away. The probe then has about an hour to make measurements of Jupiter's atmosphere.

During the first 20 seconds of its entry, radiative and convective heating will bring the heat-absorbing gas layer around the probe to a searing 8,317°C as radiative energy is produced by the hydrogen molecules of Jupiter's atmosphere breaking apart and recombining. Convection heating is caused by the friction of gases heated and compressed by the probe's supersonic shock layer as it descends through Jupiter's upper cloud layers.

Carbon phenolic was chosen for the outer layer because it absorbs large amounts of energy in the process of vaporising. Furthermore, this material has been used for heatshields on previous spaceflights, including the Pioneer Venus probes.

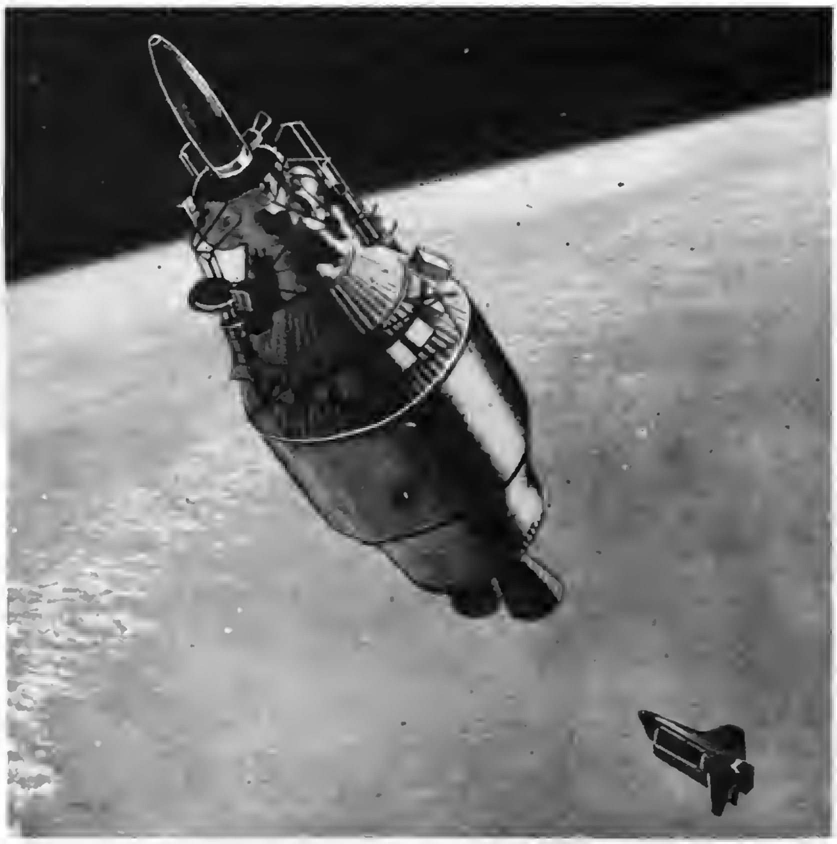
MID – AIR RECOVERIES

Rocketborne payloads launched by two single-stage Orion sounding rockets were successfully retrieved in mid-air recovery operations on 23 July 1981 by NASA's Wallops Flight Center (WFC).

The objective of the flights was to obtain vertical profiles of nitric oxide concentrations throughout the middle and upper stratosphere (30-50 km altitude) as well as to test the repeatability of the nitric oxide sensor. Both scientific experiments have flown twice before, from the Wallops range and from Red Lake in Canada, during an eclipse, and refurbished to fly again. The previous launches supported the Nimbus 7 satellite.

Two balloons and two meteorological rockets were also launched in this series to take meteorological and ozone measurements to supplement the Orion payload data.

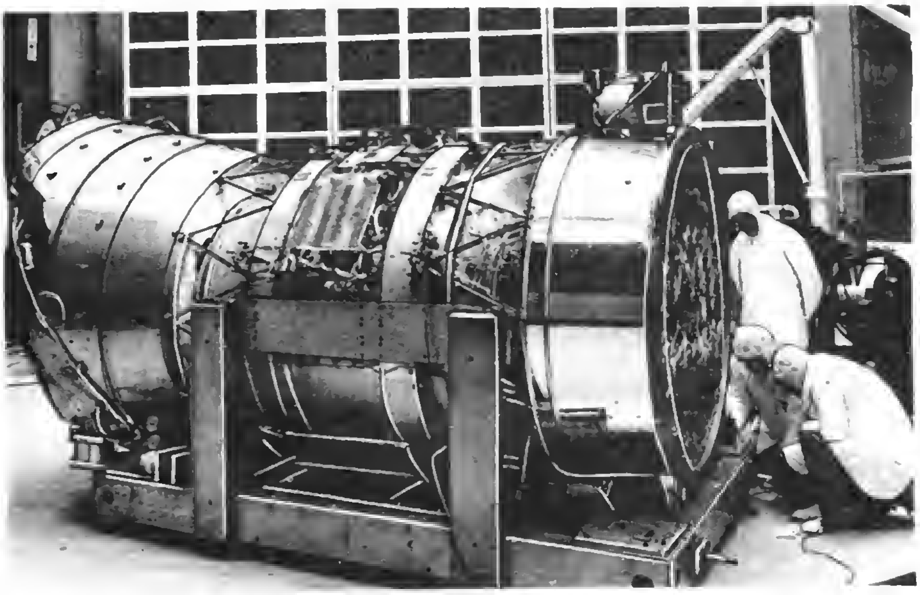
Recovery of the two experiments was achieved by a Wallops crew flying in a Skyvan aircraft equipped with special mid-air retrieval equipment to hook the parachute and winch it, and the payload, into the plane.



The Galileo Jupiter probe soon after its deployment from its Shuttle launcher. It sits on top of the Centaur high-energy upper stage with its large antenna still in the stowed position, waiting for the two engines to ignite to send it out into deep space.

Possible further cuts in space spending have placed the future of both the Shuttle-modified Centaur and Galielo craft in doubt.

General Dynamics



IRAS, the Infrared Astronomical Satellite, was shipped to the Jet Propulsion Laboratory in early October from the Netherlands where the telescope unit was integrated with the rest of the satellite.

Once at JPL, the provisional focal plane instrumentation was due to be replaced by the flight unit, in time for a launch in August 1982.

The telescope observes through the aperture seen at the left of this picture.

Fokker

SKYLAB LIVES ON

When the Skylab project finished in 1974 the second station, Skylab B, was given to the National Air and Space Museum in Washington, D.C. for display to the public. Its equipment was of flight standard and now, with the Spacelab missions coming in the next few years, some of it will fly in space.

Most of the specially-designed air circulation fans were removed from the exhibit and 25 of them found to be in working order, making them available for up to 10 flights each aboard the Shuttle.

One is scheduled to be used to circulate air in the Spacelab transfer tunnel, the passage that links the Shuttle Orbiter's mid-deck with the Spacelab habitable module mounted in the cargo bay. Another will serve as a flight spare. Two other fans will be incorporated in a cosmic ray experiment scheduled to be flown on the second Spacelab mission. In all, 13 of the fans have already been programmed for use.

These are no ordinary household fans, according to Ralph Burns of the Marshall Center's Structures and Propulsion Laboratory. They use a specially designed high-efficiency DC motor made without brushes, to prevent sparking. And they were manufactured from special materials under very stringent controls. "If we had to purchase these fans new today, it has been estimated that they would cost more than $22,000 each," said Burns.

Meanwhile, a plane-load of Spacelab equipment arrived at KSC for use in the Operations and Checkout Building during the integration of a Spacelab and its experiments. The gear will first be tested on the Spacelab Engineering Model which arrived in December 1980.

RADAR RESEARCH

A major international research facility, in which Britain has a large stake, was inaugurated by the King of Sweden on 26 August. The unique radar complex is designed to study the ionosphere and the magnetosphere at auroral latitudes from observing stations in Kiruna (Sweden), Tromso (Norway), and Sodankyla (Finland). It will enable scientific groups in Europe to conduct new investigations into a wide variety of phenomena as well as into many basic plasma problems.

Essentially, such work will make a significant contribution to an understanding of the physical processes in the magnetosphere (300 km and upwards) and the high latitude ionosphere (about 80 to 300 km) and to the complex interaction between the Sun and the Earth's upper atmospheric layers. The observations will be based on the scattering of radio waves from free electrons in the upper atmosphere, using two high-powered radar installations. These consist of a UHF transmitter in Tronso and receiving antennae in Tromso, Kiruna and Sodankyla, and a VHF transmitter and receiving antennae in Tromso.

The facility is being set up and will be run by the European Incoherent Scatter Association (Eiscat), with headquarters in Kiruna. Eiscat's annual operating budget is about £1 million, of which the British member - the Science and Engineering Research Council (SERC) - contributes 25%. Total investment in equipment and buildings for the project is £13 million.

EXPLORERS IN ORBIT

British space scientists have a particular interest in the Dynamics Explorer mission launched on 3 August by NASA from the Western Test Range in California. The mission comprises two spacecraft which were launched on a single Delta 3913 into near and far Earth orbits (although the orbits were not as planned). The primary purpose of the programme is to make a detailed study near the Earth of the effects of energy transferred from the hotter, tenuous and convecting plasmas far out in the Earth's magnetosphere into the dense and relatively cold gases of the upper atmosphere and ionosphere. These processes create phenomena in the upper atmosphere such as aurorae - the so-called northern and southern lights - particularly when the outer regions of the Sun flare up.

Aboard the low-altitude spacecraft is a new optical interferometer that has been jointly developed by the University of Michigan and University College London (UCL) and which will accurately sense from space the wind and temperature structure of the upper atmosphere. The use of well-proven techniques on board both spacecraft in conjunction with the new interferometer gives the space mission the unique possibility of investigating phenomena in regions of the Earth's atmosphere previously unavailable to space scientists because of a lack of suitable instrumentation.

The first image from Himawari 2 (Geostationary Meteorological Satellite 2) was received at the Meteorological Satellite Centre in Japan on 7 September. The satellite was launched on 11 August and injected into geostationary orbit the following day.

Following initial performance tests, the satellite was due to be moved to its permanent orbital slot at 140°E from its provisional position at 160°E to replace its predecessor.

The picture clearly shows Australia at lower left.

NASDA

A stable, high resolution Fabry-Perot etalon provides the interferometer with its capability to sense the Doppler broadening and wavelength changes associated with upper atmospheric temperatures (500-1500 K), and winds (up to 1000 m/s).

Most of the scientific results from the Dynamics Explorer satellites will be processed at the Goddard Space Flight Center, Maryland. US scientists in 12 laboratories will be able to gain access to the computer and data base directly through a data network that NASA has been developing for some years and which has been used only once before. The UCL group has a local computer which connects to the NASA system *via* a trans-Atlantic telephone link enabling information specific to UCL investigations to be retrieved. A pre-launch description of the satellites was given in the August-September issue of *Spaceflight* (p.223).

PIONEER 10'S FINDINGS

In November's *Spaceflight* we reported that Pioneer 10 had reached the 25 AU mark in its journey away from the Sun. Since its launch in 1972 Pioneer 10 has been returning data on the heliosphere — the solar atmosphere.

The heliosphere is now believed to be a huge, tear-shaped magnetic bubble created by the solar wind. Its shape comes from streamlining due to motion of the Solar System through the interstellar gas. The skin of the bubble, the boundary region with the interstellar gas, is believed to lie between 50 and 100 AU from the Sun.

The solar wind travels at an average of a million miles per hour away from the Sun in all directions, dragging the Sun's magnetic field with it. This bubble, which probably extends far beyond Pluto, is believed to breathe, expanding and contracting like a giant cosmic lung with each 11-year solar cycle.

Recent findings show that as storms on the Sun build up toward maximum solar activity, they send out shock waves throughout the bubble that cause ripples like those created by a pebble dropped at the edge of a pond. These ripples may live in the heliosphere for over a year, causing it to change shape like a huge jellyfish, as well as expand and contract.

This long-lived solar storm turbulence accelerates low energy cosmic ray particles incoming from the Galaxy, deflecting them out of the Solar System, and shielding the planets. Near solar storm maximum, even high energy (high speed) cosmic ray particles are shut out. However, Pioneer is finding, as its distance from the Sun increases, more and more cosmic ray particles penetrate the heliosphere.

Solar storms (also known as solar flares) apparently trigger the Earth's weather cycles. They cause electro-magnetic storms and radio blackouts, distort navigation, and overload power systems.

The Sun's magnetic field, like the Earth's, has two poles. The entire heliosphere is split by a current sheet, extending out from the solar equator. The sheet separates the northern magnetic hemisphere from the southern magnetic hemisphere. This current sheet, and the interplanetary magnetic field, is warped by solar storms, making the Sun look like it is in the middle of a flapping disc. Scientists now believe the current sheet extends to the heliopause, the boundary region between the Sun's atmosphere and the interstellar gas (the medium between the stars).

Near Earth, Pioneer data shows, the solar wind blowing away from the Sun is made up of from two to ten immense fast and slow streams. By the time the solar wind passes Uranus, the fast streams have caught up with the slow streams and created one stream that travels at the average speed of the slow and fast streams combined. Here the stream boundary turbulence almost disappears.

Within the Solar System, one planet behaves as if it were a small sun. Jupiter, at 5 AU from the Sun, spews out high-speed streams of electrons that travel at least two billion miles, producing a lighthouse effect as they rotate with the planet. Because these clearly non-solar electrons are bent by the Sun's magnetic field, they are useful tools in investigating the character of this magnetic field.

Before the discovery of the Jovian electrons, scientists felt planets had little effect on the heliosphere. However, these electrons could cause an interchange of energy between Jupiter and the heliosphere — and Jupiter appears to be losing energy while the rest of the heliosphere is gaining energy.

Scientists expect Pioneer 10 to fill in more pieces of the puzzle as it continues its journey away from the Solar System.

ECHOES OF ECHO

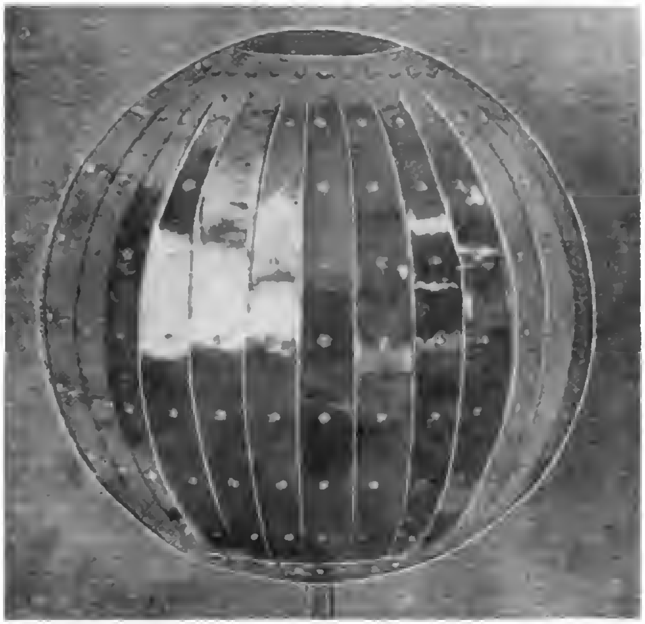
Many people will remember the 100 ft diameter Echo 1 and 135 ft Pagcos balloon satellites — they were easy to spot in the night sky for years — as the largest payloads ever launched into space, writes Andrew Wilson. Other balloons also went into orbit but that type of satellite has been off the space scene for years now. But perhaps not for long. The Japanese are planning to use one of their H-1 launcher test flights sometime in 1985-86 to fire aloft a 13 m (42 ft) balloon carrying 2,000 laser reflectors on its outer skin.

Geodetic Satellite-1 (GS-2) will carry out the same sort of geodetic mission that the American Pageos flew, allowing an accura'e network of positions to be built up covering the many Japanese islands and thence relating it to the rest of the world.

The sphere will be built up of about 50 sections (gores) of very thin material — the US balloons used aluminised Mylar — with 4 cm (about 1½ in) diameter laser reflectors studded over its surface. The Japanese Geographical Survey Institute and the Hydrographic Department of the Maritime Safety Agency began conceptual studies in 1969 and decided that simply photographing a Sun-illuminated sphere against the stellar background was not accurate enough — lasers would be used at the same time.

The laser prisms will introduce problems, though. American sub-orbital tests of Echo 1 showed that it was easy to over-inflate the balloon and tear it to shreds. Prisms — 1 cm thick and weighing 20 g — will have to be carefully added otherwise they may introduce weak spots in the fabric.

GS-1 has yet to receive approval and a 10 m (33 ft) version may actually fly. If it does, its 1500 km, 50° inclination orbit will allow most of the world's population to see it as a mag. 2-4 object.



The geodetic balloon

NASDA

TOTAL ECLIPSE

The total solar eclipse of 31 July last was observed by NASA's C-141 Kuiper Airborne Observatory using a 91 cm infrared telescope in order to study the chromosphere (the relatively thin layer of the Sun's atmosphere).

The observatory aircraft was based at an Air Force Base in Japan, from where it could intercept the path of the eclipse over the northwestern Pacific.

The Gerard P. Kuiper Airborne Observatory is an astronomical research facility operated by Ames Research Center under the cognizance of NASA's Office of Space Science. It is a highly modified version of the Lockheed C-141A, a military cargo transport aircraft. The aircraft and its precision infrared telescope is a unique high-altitude observing platform which permits scientists to accurately measure the infrared radiation from planets, stars, galaxies, and now the Sun.

In most of the infrared wavelength range, water vapour in the Earth's lower atmosphere absorbs more than 90 percent of the radiation from celestial objects. As the observatory aircraft climbs to altitudes of up to 13.7 km, the transparency of the sky to infrared radiation improves dramatically and provides a new window to the universe not available to ground-based astronomers.

The path of the July total solar eclipse began at local sunrise near the Black Sea. The shadow moved eastward across the central part of the USSR, across the Kuril Islands, and then southeasterly across the Pacific Ocean, ending at local sunset northwest of Midway Island:

The observatory flew through the Sun's shadow over the North Pacific in a southeasterly to northwesterly direction, spending only about one-and-a-half minutes in the darkness of the total eclipse, during which the telescope was trained on the Sun's limb as the bright disk was masked by the Moon.

FIRST BLACK BRANT X LAUNCH

A new high performance sounding rocket, the three stage Black Brant X (BBX), was launched from NASA Wallops Flight Center on 14 August. The flight was highly successful, reaching a peak altitude of 388 miles and impacting at a range of 438 miles.

The Black Brant X (BBX) sounding rocket is being developed by the NASA/Goddard Space Flight Center in a cooperative effort with the Canadian National Research Council, Bristol Aerospace Limited, the Swedish Space Corporation, and SAAB-Scania Corporation. The primary objective of the test flight was to demonstrate the capability of the BBX and its payload systems to investigate the Earth's polar cusp and to conduct other space science missions.

The propulsion for the BBX consists of a Terrier MOD I as first stage, a Black Brant VC (BBVC) as second stage, and the newly developed Nihka motor as third stage. Four fins are used on both the first and second stages to provide static stability and desired roll rate. The third stage of the BBX is gyroscopically stabilised using the spin rate imparted from the second stage fins. A SAAB-built S-19 Boost Control System located in the second stage payload is operated for the first 18 seconds of flight to reduce trajectory dispersion. Bristol Aerospace builds the BBX second and third stage motors and much of the flight hardware. Much of the BBX flight analysis is performed for Goddard by GE MATSCO.

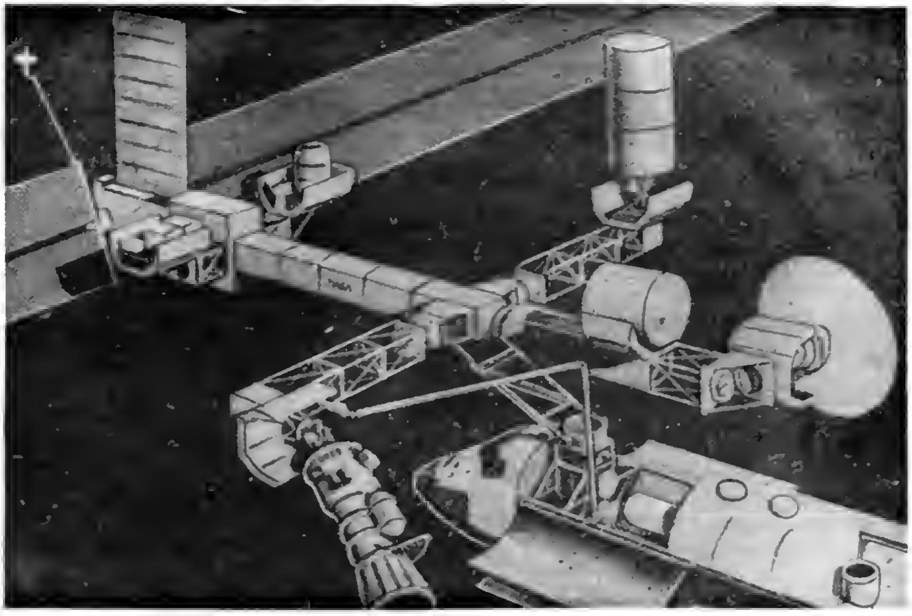
On this first flight a second stage telemetry system was carried to monitor BBVC chamber pressure and information on the operation of the S-19 and the second-to-third stage separation system. The third stage igniter housing was equipped with a yo-yo despin system and a third stage payload separation system. The third stage payload consisted of performance instrumentation, a magnetic attitude control system (ACS), an ejectable nose fairing, deployable dummy

A Space Platform concept under study at Marshall Space Flight Center, weighing 26,000 lb and intended for launch in 1987 to low Earth orbit.

The Platform carries three docking ports so that Shuttle missions can attach unmanned experiment packages and leave them there for months at a time. The illustration shows an experiment incorporating a Spacelab module being attached.

A Spacelab manned module could be added later, turning the Platform into a permanently manned space station.

NASA



experiment booms, a small nutation damper experiment and suitable balance and ballast weights. The newly developed ACS is designed to align the spinning payload with the Earth's magnetic field during the period of scientific data collection.

NASA planned to launch at least four BBX rockets for scientific investigations during the following nine months — two from Cape Parry in Northwestern Canada and two from Poker Flat Research Range in Alaska.

NASA APPOINTMENT

Maj. Gen. James Abrahamson, an ex-Manned Orbiting Laboratory astronaut, has been named as Associate Administrator of NASA's Office of Space Transportation Systems. He replaces John Yardley who left to become president of McDonnell-Douglas Astronautics.

SPACE AT PARIS '81

The 1981 Paris Air Show featured few new items of space hardware, in contrast with previous years when the Soviets at least revealed new items of their spaceflight inventory, writes Neville Kidger. However, in the year of the 20th anniversary of Gagarin's flight, the Soviets chose to show the difference in the spacecraft of that era with the orbital stations of today.

The Soviet pavilion featured full-scale replicas of the Vostok 1 spacecraft, in which Gagarin made a flight of 108 minutes, and the Salyut 6/Soyuz/Progress space complex, in which 27 cosmonauts worked and two stayed for periods up to 185 days. Also on view were descent modules of both Vostok and Soyuz, which looked real — even down to the shredded insulating material on the Soyuz exterior. It was possible to go inside the Salyut space station and look at the shower, food, beds and other items which support the life of cosmonauts in orbit. Cosmonaut Valeri Ryumin made a brief, unannounced, appearance.

Other Soviet hardware displayed included a full-scale mock-up of the Gorizont communications satellite, through which some of the TV of the 1980 Olympiad was broadcast, a Salyut EVA space suit, Progress cargo module, FCC control panel from Kaliningrad and several models of the scientific equipment used by Salyut 6 cosmonauts, including biological and technological installations and torqueless tools. A film of the Soyuz 22 mission was continuously shown in the cinema.

The NASA pavilion did not dwell on history but showed future projects, with models of the Galileo Jupiter Orbiter probe and Landsat D spacecraft hanging above visitors' heads. Largest display in the NASA pavilion was a mock-up of the Shuttle orbiter flight deck, with two dummies at work inside it. Above that was an astronaut in full Shuttle EVA regalia flying, as if in space, with the aid of a manoeuvring unit. A video show

SPOT, the French Earth resources satellite, is scheduled for launch by Ariane in 1984.

CNES

accompanied the display with actual space footage from the STS-1 flight. Other audio-visual displays illustrated other areas of NASA's space and aeronautical activities.

On the way out it was possible to touch a highly polished piece of a Moon rock brought back by Apollo astronauts. The black rock, only a portion of which was exposed, resembled a piece of formica.

In the French Space Agency's hall was a full-size mock-up of the SPOT Earth observation satellite in its Ariane payload shroud. This provided a marked contrast to the payload shroud of the French-developed Diamant launcher which lay beside it.

The three-story exhibition featured many satellite models, including Symphonie, Peole, OAO and the Shuttle. The upcoming flight of a Frenchman to a Soviet Salyut space station was illustrated by a small model of the Salyut 6 space station, autographed by the cosmonaut trainees themselves. Photographs of the two men in Star City, near Moscow, were around the model.

Arianespace, the company formed to market the launcher, featured actual production hardware of the ESA launcher and models of future development versions, planned for the mid-1980's. A slide show, with as many as eight separate simultaneous images, illustrated the manufacture and launching of the rocket.

Highlight of the ESA pavilion, apart from the warm hospitality of the staff, was a mock-up of Spacelab with two dummies inside who described the functions and purpose of the laboratory. Live TV from London *via* OTS-2 was featured on one wall while models of Meteosat and Sirio 2 were also shown. From the display it was possible to see that ESA is proceeding with the development of space for the benefit of Europe.

NASA CENTERS MERGE

Several NASA Centers merged in October to streamline their operations. Dryden Flight Research Center and Ames Research Center, both located in California, merged, with Dryden becoming an operational element and component installation of Ames. Goddard Space Flight Center, in Maryland and Wallops Flight Center (WFC) on the Eastern shore of Virginia, also merged, with Wallops becoming an operational element and component of Goddard. Dryden and Wallops retain their identity, but are under the overall management and direction of Ames and Goddard respectively.

The consolidations are aimed at focusing the resources of the installations on what they can do best. The close relationship between Wallops' and Goddard's efforts in suborbital programmes were instrumental in the decision. To use the unique capabilities at Wallops, sounding rocket development and operations for both Centers will be carried out primarily at Wallops.

SOLAR OPTICAL TELESCOPE

NASA's Office of Space Science has selected two scientific investigators to develop instruments to fly aboard the planned Solar Optical Telescope, first due for launch aboard the Shuttle in 1987.

Dr. Harold Zirin proposes developing a photometric filtergraph which will be able to observe the Sun through various optical filters in the near infrared, visible and ultraviolet regions of the spectrum. The proposed instrument will be able to take several hundreds of images on film during the one-week mission of the Solar Optical Telescope.

Dr. Alan Title's proposal is for a coordinated filtergraph and spectrograph which will include a tunable visible-light and optical filter system and a high resolution spectrograph with motion compensation. The spectrograph will operate in both the visible and ultraviolet spectral regions. Both the filtergraph and the spectrograph will record data using charge-coupled device imaging systems, and relay the information directly to the ground for examination by scientists.

These two instrument assemblies will be located at the focal point of a 1.25m diameter telescope mounted on a pointing system located within the Shuttle payload bay. The Solar Optical Telescope will be designed for a variety of solar physics investigations on several Spacelab flights.

The current timetable for the first flight of this instrument, which is expected to expand considerably on the so-far unsurpassed results of the Skylab Apollo Telescope Mount, shows initial launch in the spring of 1987 with reflights scheduled thereafter.

ESA ASTRONAUTS

The two ESA Payload Specialists, Claude Nicollier and Wubbo Ockels, successfully completed their basic astronaut training for mission specialists, which they began in July 1980 at the NASA Johnson Space Center. They have acquired the basic qualifications for becoming European Mission Specialists. NASA agreed to include Europeans in their astronaut training programme in recognition of the substantial contribution ESA is making to the Shuttle by developing Spacelab. The third European Payload Specialist, Ulf Merbold, has in the meantime worked with the European experiments selected for the first Spacelab Payload (FSLP).

As from October 1981 Wubbo Ockels rejoined the SL-1 crew (First Spacelab Mission), in order to complete his training as FSLP Payload Specialist. During this training period, carried out in Europe as well as at MSFC and JSC in the USA, he will join forces with Ulf Merbold, the two US Payload Specialists and the two US Mission Specialists. The final selection of the FSLP Payload Specialists, i.e. one European and one American, will take place about 6 months prior to the flight, presently planned for September 1983. Claude Nicollier stays at JSC to continue his dedicated training as Mission Specialist with a view to obtaining full capacity in this field for future Shuttle missions carrying European Payloads.

Ulf Merbold maintains his status as European Payload Specialist.

IUE CONFERENCE

The International Ultraviolet Explorer (IUE) has now been in orbit for almost four years, relaying data to Earth on the ultraviolet Universe. It was launched on 26 January 1978 carrying a 45cm (17.5in) diameter Cassegrain telescope and two spectrographs with UV cameras sensitive to light from 1150 and 3200 Angstroms in wavelength. The Earth's atmosphere prevents these wavelengths from reaching ground-based telescopes.

A 3rd European IUE Conference will be held in Madrid on 4-6 May to assess the impact of IUE on our knowledge of quasars, pulsars, etc.

HIPPARCOS

A Colloquium on the scientific aspects of the Hipparcos astrometry satellite mission is to be held in Strasbourg on 22-23 February 1982.

The Hipparcos mission will result in a catalogue of the positions, proper motions and parallaxes of about 100,000 stars.

THE SPACELAB 2 AND 3 MISSIONS

The Spacelab 1 mission will demonstrate the wide range of capabilities of the space laboratory, part of which will be the pressurized module. Spacelab 2's scientists will work from the confines of the Orbiter's deck since the payload bay will be filled with pallets carrying experiments from various scientific disciplines. Spacelab 3 will see the return of the pressurized module for technological experiments.

Introduction

Spacelab 2 will be the second flight of a modular European-American orbiting laboratory aboard the Shuttle. Twelve experiment teams from the United States and UK will direct investigations in life sciences, plasma physics, infrared astronomy, high-energy physics, solar physics and other technology-orientated areas. Eleven instruments will fly aboard Spacelab; the twelfth experiment will be conducted from the ground using the spacecraft itself as an instrument.

On Spacelab 2 the cargo bay will be occupied only by pallets supporting various experiments, exposing them to the space environment. The payload crew will operate this experiment equipment from inside the Orbiter's crew cabin, whereas in Spacelab 1 the crew will work inside a habitable module in the cargo bay.

Also unlike Spacelab 1, the second mission is sponsored entirely by the United States. The first is to be a joint NASA/ESA mission, and will carry a mixed European/American payload crew.

Since this will be only the second Spacelab flight, a primary objective is to verify the Spacelab systems and subsystems; determine the interface capability of Spacelab and Orbiter; and measure the environment induced by the spacecraft. The secondary objective is to obtain scientific and technological data to demonstrate Spacelab's capability to conduct investigations in a number of disciplines on a single mission. A key requirement in the choice of investigations for this mission was for experiments that exercised Spacelab's subsystems and also posessed the capability of obtaining excellent and unique science. The third Spacelab mission will be the first in which Spacelab is considered operational and the primary mission objective will be the accomplishment of the individual experiment objectives.

While two pilot atstronauts will fly the mission, the crew who will actually operate the experiments will consist of two Payload Specialists and two Mission Specialist astronauts.

Spacelab 2 is scheduled to be launched aboard the Space Shuttle from the Kennedy Space Center in 1984. It will remain in space for seven days at an altitude of approximately 400 km (250 miles), returning to the Kennedy Center runway.

Spacelab 2 mission experiments

Twelve investigations have been selected to fly on Spacelab 2. Of these, 10 originate from the US and two from the UK.

The life sciences experiments will examine the effects of zero gravity on the metabolosim of both plants and animals. The formation of lignin in plant seedlings in a controlled oxygen environment will be studied, and the derangements of mineral metabolism in humans during prolonged spaceflight will be monitored. Plasma physics experiments will investigate the interaction of the Orbiter with the magnetosphere from a deployed subsatellite. The Orbiter thrusters will also be used to create regions of electron depletion in the ionosphere which can be monitored from ground-based observatories.

An infrared astronomy experiment will monitor contamination in the Orbiter's vicinity and will spatially map extended sources of infrared radiation over much of the sky. The results will complement studies of compact infrared sources being made about the same time by the Infrared Astronomical Satellite (IRAS). A high-energy experiment will determine the charge composition of energy spectra of cosmic-ray nuclei at energies previously unobservable from the ground. In addition, an X-ray telescope will be used to study X-ray emission from clusters of galaxies in an attempt to resolve emission mechanisms.

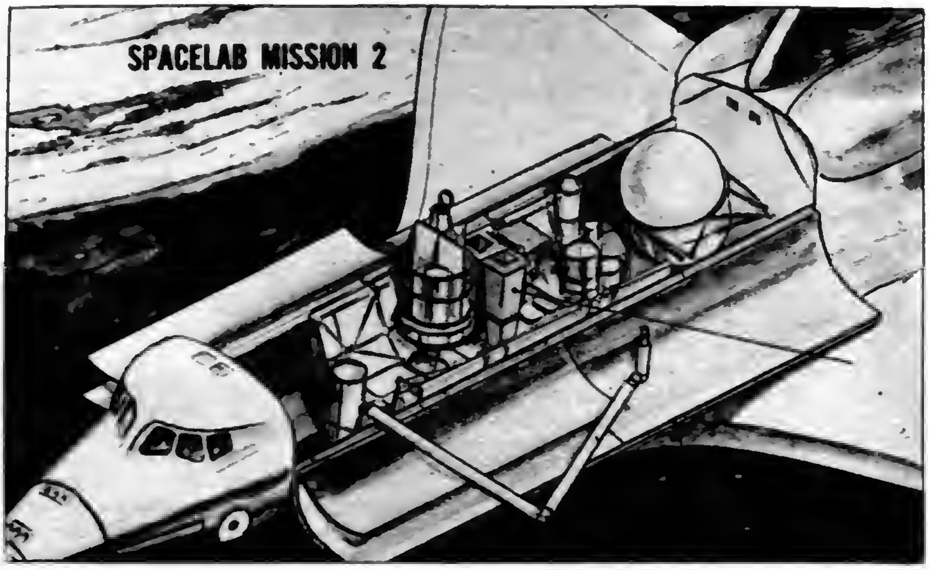
The solar physics experiments will include a study of small-scale solar-magnetic and velocity field structures with high temporal spatial resolution and a high-accuracy determination determination of the absolute abundances of helium in the solar corona. In addition, an examination will be undertaken with high spectral and spatial resolution of intensity fluctuations, Doppler shifts and line profile changes which are crucial to the understanding of the mechanisms responsible for the heating of the chromosphere, transition zone and corona. An atmospheric science experiment is aimed at establishing the total solar ultraviolet flux with high accuracy and its charges over a solar activity cycle.

A technology experiment will measure the thermal and fluid properties of superfluid helium in zero gravity as requisites for future space experiments using superfluid helium as a cryogenic substance.

Many of the investigations capitalise on the new capabilities

The four Payload Specialist candidates for Spacelab 2 during a visit to the Marshall Space Flight Center. Left to right are Loren Acton, George Simon, (W.R. Lucas, MSFC Director), John-David Bartoe and Dianne Prinz. Two will be selected to fly in the mission.

The layout of the Spacelab 2 experiment pallets, described in the main text. The Remote Manipulator will be used to deploy a sub-satellite for a plasma physics experiment in the Earth's magnetosphere.



of Shuttle and Spacelab. For example, the Orbiter's weight-carrying capacity allows the use of a massive instrument such as the cosmic-ray experiment (1,784 kg or 4,000 lb) plus several other large instruments.

The plasma diagnostics package will demonstrate the use of the Shuttle remote manipulator system, the capability of the Orbiter to launch subsatellites and the ability of the Orbiter to manoeuvre the subsatellite in space. The four solar-orientated experiments will use an instrument pointing system developed by ESA. The flight of Spacelab 2 represents a pioneering effort and the results obtained from the mission will benefit a wide range of scientific inquiry. It will provide an important insight into many of the physical processes occurring on Earth and in space, thus establishing another step in our basic understanding of our Universe.

Nine of the 12 experiments are on three pallets in the payload bay. In addition, a special structure has been designed to support the cosmic-ray experiment. The two life sciences experiments will be carried in the Orbiter mid-deck and one experiment involves only observations from the ground.

Payload specialists

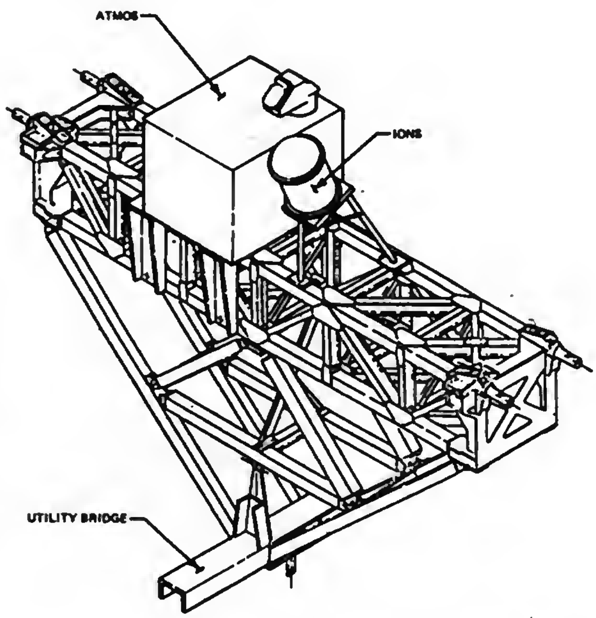
Payload specialists are new to NASA. On Spacelab 2, they are to be non-NASA scientists who will go into space to operate their own experiments and the experiments of other scientists responsible for preparing investigations for the mission.

They were selected by their peers in an Investigators Working Group made up of all Spacelab 2 experimenters. The chairman of the working group also serves as Spacelab 2 mission scientist. He is Dr. E. W. Urban, chief of the Cryogenic Physics Branch of the Space Sciences Laboratory at NASA's Marshall Space Flight Center, Huntsville, Ala. The Marshall Space Flight Center is responsible for managing all aspects of mission preparation and conduct of the first three Spacelab missons.

The four Payload specialists selected by the working group in 1978 are now training. The two who will actually fly aboard the spacecraft will be indentified later. The two not chosen to fly will support experiment operations from the payload operations control centre on the ground. The four are: Dr. Loren W. Acton, Lockheed Palo Alto Research Laboratory, Calif.; Dr. John-David F. Bartoe, U. S. Naval Research Laboratory, Washington, D. C.; Dr. Dianne K. Prinz, U. S. Naval Research Laboratory, Washington, D. C.; and Dr. George W. Simon, Air Force Geophysics Laboratory, Sacramento Peak Observatory, Sunspot, N. M.

The non-astronaut payload specialists, who will operate the experiments aboard Spacelab missions, will undergo two basic types of training: mission-independent and mission-dependent.

Mission-Independent Training. Regardless of payload scientific objectives, all flight personnel must possess certain fundamental skills necessary to live and work safely aboard the Shuttle and Spacelab. The training required to impart these skills is termed mission-independent in such areas as habitability, medical, emergency, survival operations and launch site familiarization. The NASA-Johnson Space Center, Houston, has the responsibility to both define and implement the major portion of this training. Those portions applicable to the launch and landing sites are the responsibility of the NASA-Kennedy Space Center.



Two structure-mounted experiments, Atmos and Ions, of Spacelab 3. Atmos will search for trace molecules in the atmosphere while Ions will observe low energy heavy ion radiation.

The Spacelab 2 and 3 Missions/contd.

Mission Dependent Training. The training associated with the experiments constituting a particular Spacelab payload is called mission-dependent. Most of the training in this category will involve the detailed operation of individual experiments and will be defined by the investigators themselves and conducted at their laboratories (or at ESA/SPICE for European experiments). Later phases of this training will include operation of the entire assembled payload. The mission-dependent training will culminate in mission simulation activities involving walk-throughs of various mission segments in the final weeks prior to launch.

The new aprroach to training shifts much of the responsibility for experiment training from NASA to the various experimenters themselves. However, the Marshall Center mission manager plans and coordinates this training and provides facilities and services for intergrated payload operations training. The Marshall centre will manage the training activites in the United States and Europe as part of its overall management responsibility for the first three Spacelab Missions. ESA's Spacelab Payload Intergration and Coordination in Europe (SPICE) organisation will coordinate the training activities in Europe.

The payload specialists will also be trained in Space Shuttle Orbiter and Spacelab systems to the extent necessary to live and work in the space environment.

At a designated time in the training cycle, two of the four payload specialists, one ESA and one NASA, will be selected to actually fly aboard the mission and the others will be assigned Earth-based duties. After that selection is made, the flght payload specialists will concentrate more on procedures and flight mission operations. The goal is to reduce the payload specialists training time for later missions to about 12 months. This would reduce the time that the scientist must spend away from normal research activities.

Spacelab will begin where Skylab left off in its work in space - about a decade later.

Spacelab 3

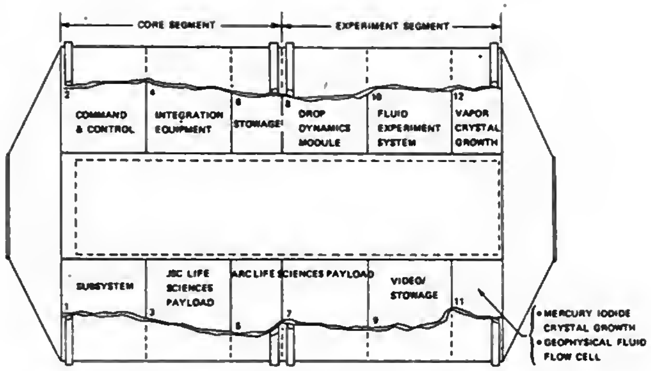
Spacelab 3 will be the first operational flight. Experiments will be conducted in the applications, science and technology disciplines with emphasis on materials processing. This requires the low gravity environment of Earth orbit with minimum vehicle attitude manoeuvres.

Spacelab Mission 3, seven days in length, is scheduled to be launched from Kennedy Space Center in the 1984-85 time frame. On-orbit activities for the crew of six will be conducted 24 hours a day in a 370 km (200 nautical mile) high orbit inclined at 57 degrees. A single orientation, conducive to sustaining low gravity, will be maintained for the full duration of the mission.

Spacelab 3 mission experiments

Fifteen investigations will fly, 13 originating from the United States while one is sponsored by India and one by France. Thirteen are located in the module, and two - Atmospheric Trace Molecule Measured by Spectroscopy and Ionization States of Solar and Galactic Cosmic Ray Heavy Nuclei are on the support structure in the payload bay.

The module experiments on Spacelab mission 3 will use the planned low gravity environment. For example, in the materials processing discipline, the mercuric iodide crystals will be grown from a vapour in the Vapor Crystal Growth apparatus. The high quality crystal will be obtained by avoiding the problem of strain produced by the crystal's weight during growth, as occurs in Earth laboratories. The Fluid Experiment System crystals will be produced from a liquid, also resulting in more uniform crystals with fewer faults than those produced on



Spacelab 3 experiment module layout, locking down from above.

Earth. Improved crystal quality will enhance our ability to measure various types of radiation. The Mercury Iodide Crystal Growth Experiment sponsored by the French Space Agency (CNES) will also attempt to grow near-perfect single crystals which can lead to improved radiation detectors.

Two experiments in fluid mechanics are planned which require a low gravity environment as well as an extended duration of stable vehicle attitude. One experiment entitled Dynamics of Rotating and Oscillating Free Drops will be performed using the Drop Dynamics Module. In this experiment, basic studies on the dynamics of spinning and vibrating drops will be made with a view toward confirming predictions and gaining insight into processes not currently accessible by theory. Investigations could provide insight ranging from the micro (fusion processes) to the macro (star behaviour). A second fluid mechanics experiment, the geophysical Fluid Flow Cell experiment, is aimed at the study of convection processes found in planetary atmospheres and interiors of stars. It will attempt to confirm predictions related to the dynamics of the Sun's convective zone and the atmosphere of Jupiter.

The life sciences experiments being conducted by Johnson Space Center and Ames Research Center will evaluate the performance of specially designed equipment and facilities for use in a low gravity environment. This should optimise the experimental capabilities for life sciences research in future Spacelab missions. Both human and animal subjects will be used in a variety of measurement and observation activities for the acquisition of physological, behavioural and morphological data for later analysis and study.

One of the support/structure-mounted experiments, the Atmospheric Trace Molecule Measured by Spectroscopy, will make observations of trace gases and constituents (natural and artificial) during Earth sunrises and sunsets.

These will provide a global mapping of trace molecules in our atmosphere and lead to a better understanding of the various processes taking place in the upper atmosphere.

The other experiment, Ionization States of Solar and Galactic Cosmic Ray Heavy Nuclei, sponsored by the TATA institute for Fundamental Research, Bombay, India, is designed to make direct measurements of the charge of low energy heavy ions crucial to the understanding of observations taken on Skylab and other satellites. Information of the ionization states of solar heavy nuclei that may be provided by this experiment is of immediate interest in the understanding of the acceleration and confinement of particles in the Sun.

Spacelab 3 is the first mission in which a low gravity environment will be strictly maintained in orbit. Furthermore, the vehicle will be operated in a single orientation for the duration of the mission and drift will be carefully controlled. The conditions present unique but necessary conditions for conducting most of the experiments on this multidisciplinary mission.

NEWS FROM THE CAPE

By Gordon L. Harris

SHUTTLE TURNAROUND

Turnaround is NASA's term for the time required to refurbish its Shuttle after flight and prepare it for the next mission. In the flush of elation associated with a new, multi-billion dollar system the agency talked about 160 hours and on that basis, forecast hundreds of flights in the first decade.

Sobering experience has changed optimistic predictions. *Columbia* spent an entire year at the launch base before its April 1981 debut. Five months elapsed before a second liftoff. And Kennedy Space Center planners admit they will be happy to achieve a 10-weeks turnaround by Flight 9 in 1984. Yet agency plans call for 334 launches in the next 10 years.

A Shuttle Turnaround Analysis Group has been formed to investigate alternatives to increase the current launch rate. George Page, who directs *Columbia* preparations, expects to get off the fourth and final test mission before mid year. If he succeeds, NASA may conduct its first operational flight in September 1982 with the initial landing at this launch base. Thereafter all NASA launched shuttles would lift off and return here while the military vehicles will fly out of Vandenberg Air Force Base, California and land there beginning in 1985.

Shortening turnaround translates into fewer dollars and that is another driver NASA must keep in mind to reduce the cost of transporting satellites into orbit.

A new problem associated with shuttle launches came to light when Columbia was transferred to the launch pad during 31 August last. The agency issued a statement explaining Shuttle effects on the environment. A cloud of exhaust products caused temporary and localised degradation in air quality near the pad. The cloud travelled north and hydrogen chloride and dust were measured by ground and airborne instruments. Airborne concentrations ranged from 16 parts per million peak at 10 minutes to 2 ppm at two hours after launch. These levels were not considered excessive. Aluminium oxide dust was deposited several miles to the north and close to the pad the dust was acidic and caused spotting of vegetation. The affected area did not exceed four miles in any direction.

Sound levels were measured at 111 decibels three and a half miles from the pad. They were close to the predicted levels and similar to the sound produced by Saturn/Apollo vehicles. No significant effects on wildlife were observed by US Fish and Wildlife Service teams.

NASA may turn over its space shuttle system to private industry when development tests are completed. The agency's new administrator, James Beggs, chaired one of two studies that recommended this alternative. His group represented the National Association of Public Administrators. A similar study by Aerospace Corp., a consulting agency supported by the US Air Force, reached a similar conclusion.

A third consultant firm, Booz, Allen and Hamilton, maintains offices at Kennedy Space Center. BAH found that the agency could realise greatest economy by combining manufacturing contractors for the system into a single contract. Another firm would process cargo while a third would provide housekeeping support to both. W. E. Backus, chief of planning at the Florida launch base, pointed out that the studies concluded that NASA should continue in the role of operator for a while but should introduce changes that would permit translation to a 'quasi or fully commercial operation.'

Presently NASA employees sign all test procedures, attend all operations, coordinate contractor effort, and make schedule decisions. Backus said the studies proposed drastic changes so that fewer government personnel would focus attention on contractor performance and get out of day-to-day paper work. This concept would free more NASA employees to continue their historic role in research and development in aeronautics and space exploration.

Damage around the area of the nitrogen tetroxide fill line in *Columbia's* nose illustrates how serious the accident of 22 September turned out to be. Work on the damaged tiles pushed the launch date back to November. *NASA*

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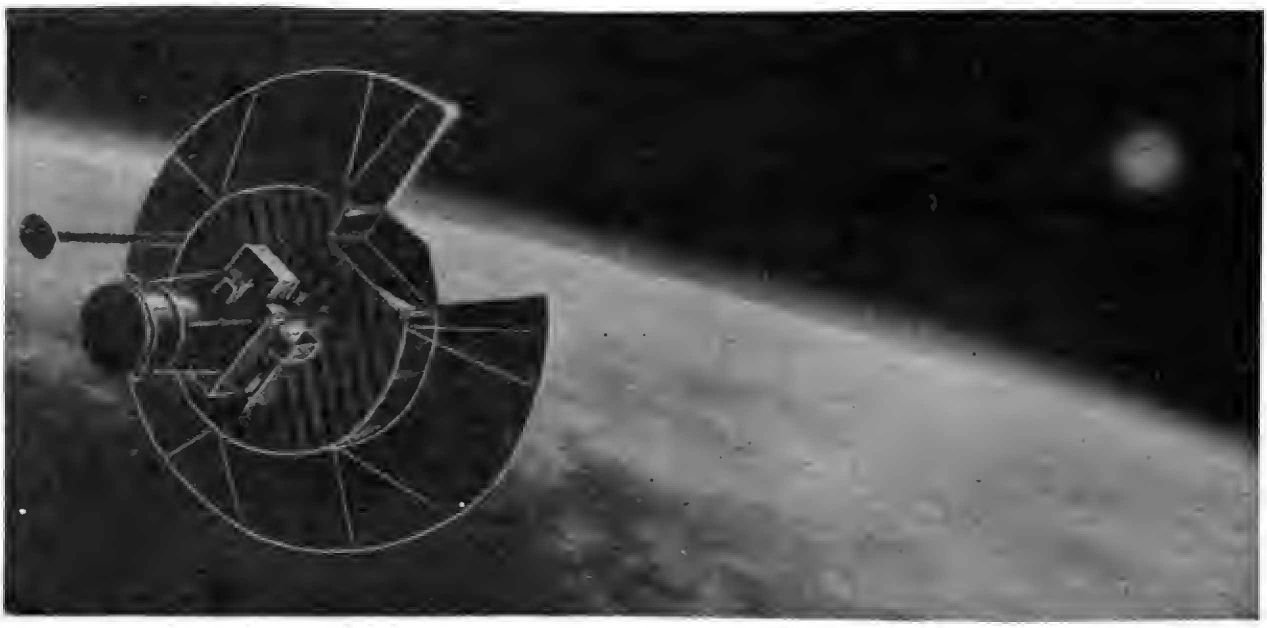
THE SOLAR MESOSPHERE EXPLORER

By Andrew Wilson



Introduction

The scare in recent years that pressurants from aerosol cans were seeping up towards the stratosphere and destroying the ozone layer has helped to underline the delicate balance between nature and man-made pollutants. The theory caught the public imagination for a while and there is no denying that ozone *is* a vital part of our atmosphere. It absorbs ultraviolet radiation from the Sun to perform the double duty of protecting the ground from harmful short wavelength radiation and warming the atmosphere. The heat, like that in processes involving water vapour, is involved in the generation of weather systems.

So extending our knowledge of the quantities of ozone in the stratosphere and mesosphere, how they are distributed over the globe, and how they vary with time, is an important step in building a reliable model of our atmosphere.

Sounding rocket measurements have been made for some years but these are limited in number and cannot give us a comprehensive *global* view of what is going on. A satellite is obviously required. The Solar Mesosphere Explorer (SME) was launched on 7 October from California into a Sun-synchronous polar orbit to take measurements over the entire Earth, each area at the same local time every day. (The Delta 2310 two-stage launcher was also responsible for orbiting the latest amateur satellite, UOSAT).

SME was proposed by Charles Barth of the University of Colorado in 1974 but it is not the first satellite dedicated to ozone research. SAGE — Stratospheric Aerosol and Gas Experiment — was launched in February 1979 by a Scout from Wallops Island but it could reach up to only 79° latitude above and below the equator. SME will extend that work to the poles over the next one to two years when solar activity will be at a maximum.

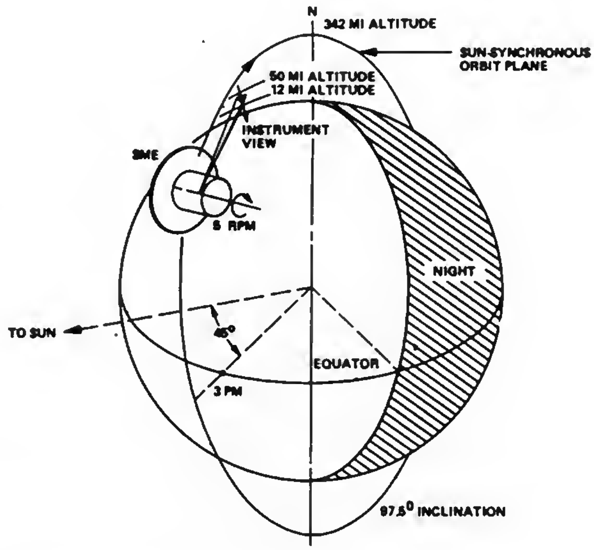
How is ozone produced?

The atmosphere between 40 and 80 km is particularly important for ozone since it is in this region that solar radiation and other gases affect its production and destruction. Oxygen (O_2) is dissociated by radiation into oxygen atoms which are then free to combine with O_2 to produce ozone (O_3). Other processes combine to destroy it: oxides of nitrogen — some of which may be there because of industrial pollution — and the products of dissociated water vapour (H and OH) all work to reduce ozone content, as does incoming radiation. The infamous aerosol cans use chlorofluoromethane whose chlorine can survive the trip into the stratosphere.

Stratosphere:	the atmosphere from 17 to 50 km height
Mesosphere:	the atmosphere from 50 to 80 km height

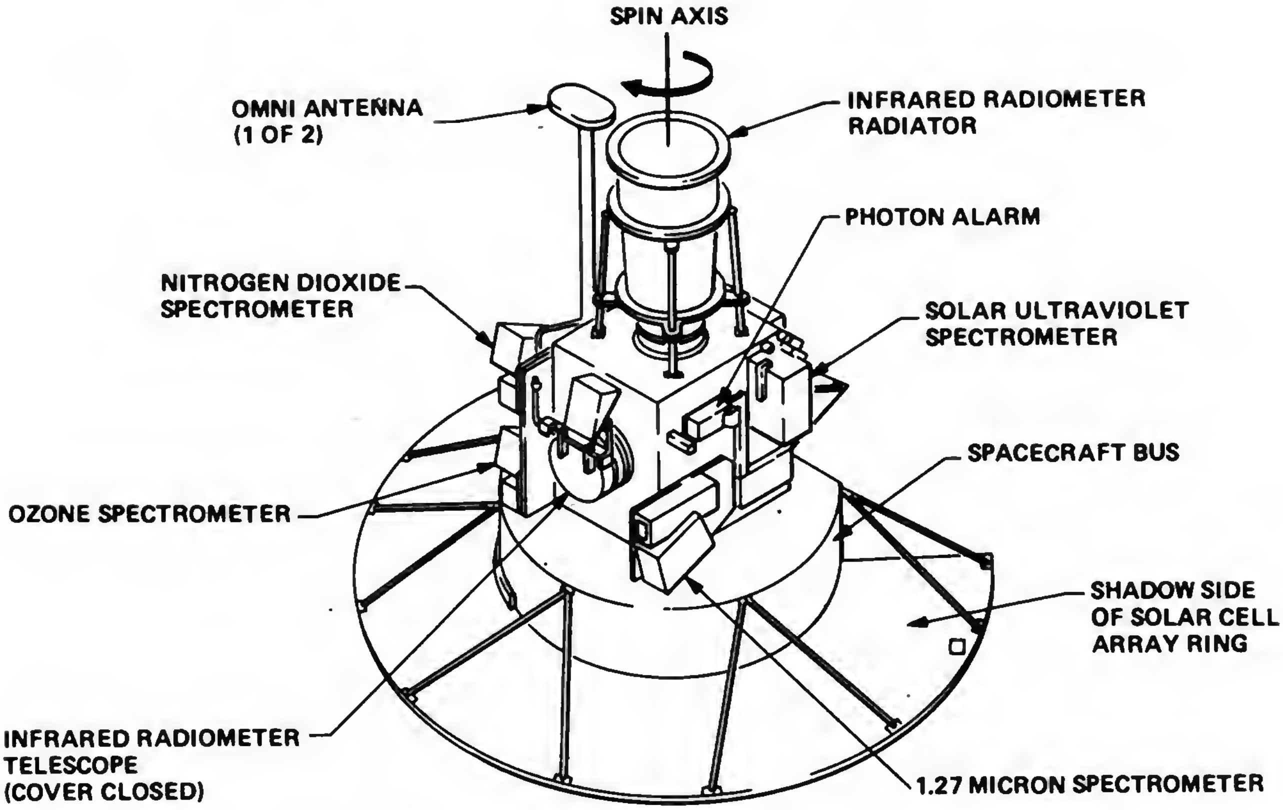
To investigate these intricate relationships SME carries five experiments as it circles the world every 93 minutes:

1. Ultraviolet Ozone Spectrometer to measure ozone quantities from 40 to 70 km.



SME's orbital path is Sun-synchronous.

All pictures courtesy of NASA



NOTE: HIGH GAIN ANTENNA AND SECOND OMNI ANTENNA MOUNTED IN CENTER OF SOLAR CELL ARRAY RING ON SUN SIDE

2. 1.27-micron spectrometer to measure ozone from 50 to 90 km, and hydroxyl (OH) between 60 and 90 km.
3. Nitrogen Dioxide Spectrometer for measurements between 20 and 40 km.
4. 4-channel Infrared Radiometer to measure temperature and pressure between 20 and 70 km, together with ozone and water vapour from 30 to 65 km.
5. Solar Ultraviolet Monitor to measure the radiation pouring in from the Sun.

The Satellite

The 437 kg spacecraft can be divided into two distinct sections: the Observatory Module and Spacecraft Bus.

The Bus carries communication, electrical and command equipment to keep the satellite running. Perhaps the most notable feature is the 1.25 m diameter disc used for mounting the 2156 solar cells directed towards the Sun to feed power into the two nickel-cadmium batteries. Internal temperatures are kept within limits by a passive system using insulating material and a network of stripes on the outer surface (rather like the old Pioneer Moon probes of over two decades ago).

The business end is the Observatory Module, carrying the five experiments. SME spins about its long axis at 90° to its orbital plane so that on every turn — five a minute — the instruments scan the atmosphere on the horizon between 20 and 80 km. The Sun monitor is mounted at 45° to the others so that it keeps a watchful eye on the solar radiation through a cut-out in the solar cell disc. Horizon sensors and a 3-axis magnetometer check the orientation and correct it using magnetic torquing if it begins to drift off.

This latest Explorer — the last two were launched in early August — should greatly extend our knowledge of the atmosphere and its processes. SME will receive much less publicity that the glamorous Voyager and Shuttle projects but its mission is no less important. A more accurate atmospheric model will eventually lead to improved weather forecasting and, in the shorter term, it should give us an idea if our industrial activities are affecting the atmosphere in a major way.

SPACE COMMUNICATIONS

SBS IN ORBIT

Satellite Business Systems' second communications satellite was launched from Cape Canaveral on 24 September to provide expanded voice, video, high-speed data and electronic mail services to business and industry throughout the US.

One of three HS 376-type craft built for SBS by Hughes Aircraft Company's space and communications group in El Segundo, California, the satellite was launched into geosynchronous orbit at 97° W longitude.

The first SBS satellite went into orbit in November 1980 and began operations early last year. The first all-digital satellite communications system in the US, it is stationed at 100° W longitude and the third, to be launched aboard the Shuttle in September, will be stationed at 94° W longitude.

SBS is owned jointly by IBM Corporation, Comsat General Corporation and Aetna Life and Casualty Company. The company offers business communication services to a fast-growing number of large companies in the United States.

Hughes is also building 100 Earth terminals for Satellite Business Systems. The satellites will operate in conjunction with these terminals, which can be installed on the roofs of buildings.

NEW SATELLITE TERMINAL

The Madley III satellite telecommunications ground terminal was handed over to British Telecom in August by Marconi, the major systems contractor. The terminal was due to go into traffic the following month.

The Madley Earth station complex was developed by British Telecom in the late 1970's, partly in order to provide diversity to the major Earth station site at Goonhilly Downs, and partly to meet the rapid growth in international calls. Marconi, which played a prominent part in the development and construction of the Goonhilly terminals, was made prime contractor for Madley 1, completed in 1978. Working to an Intelsat satellite over the Indian Ocean, it provides links to the Middle East, the Indian sub-continent, the Far East and to Australasia.

Marconi handed over Madley 2, operating to an Intelsat major path satellite over the Atlantic Ocean, in early 1980. Both Madley 2 and Madley 3 terminals are similar to Madley 1, using 32-metre antennae and operating as Standard A, 6/4GHz, Earth station terminals. Since handing over Madley 1 and Madley 2 Marconi has been involved in a constant programme of up-dating and up-rating them both to meet the growing traffic demand.

Earlier this year they completed a contract to significantly increase the traffic-carrying capacity of Madley 1 by the supply of communications equipment for dual polarisation use. A contract has been received for similar work on Madley 2.

NEW SATELLITES

The GTE Satellite Corporation is planning to have the first of two G-star communication satellites in orbit in early 1984. RCA will build three of the craft (one to be kept as a ground spare) under a $100m contract. The satellites will provide commercial services within the USA on 12/14 GHz and will be designed for launch on Shuttle, Delta 3920 or Ariane.

ANIK C2 IN PREPARATION

One of Canada's newest satellites, the Anik C2 spacecraft, successfully completed its test programme at the David Florida Laboratory last September, the first spacecraft to use these recently expanded facilities. It was then due to be shipped to Hughes Aircraft Company in California, for completion of integration in readiness for launch in the autumn of 1982. The spacecraft, the second of the Anik C series, is being built for Telesat Canada by Hughes. It is one of the HS 376 communication satellites described in *Spaceflight*, August-September, 1981, p. 205.

Anik C2 (minus some important sub-systems such as solar arrays) was functionally checked during a nine month Inte-

This experimental 14/11 GHz ground station at Goonhilly is being converted into the United Kingdom's first Standard C station. *Marconi*

PLEASE NOTE that we are changing the title of *Comsat News* to *Space Communications* to avoid any possible confusion with Comsat General Corporation.

gration and Test programme conducted by Spar Aerospace. The programme included check-out of the satellite in a thermal-vacuum chamber. Using this and many other tests, assurance of satisfactory in-orbit performance of the satellite can be made before it leaves the ground.

MORE INTELSATS

Three further Intelsat VA communication satellites have been ordered from Ford Aerospace, bringing the total of V/VA craft to 15.

Some Intelsat Vs will also have a capability for providing maritime communications services for the International Maritime Satellite Organization (Inmarsat).

The six Intelsat V-A's in the programme, which are scheduled for launch from late 1983, will carry up to 15,000 telephone calls plus television.

Satellites in the V/V-A series are capable of launch aboard the Atlas Centaur or Shuttle vehicles or the European Ariane 2 launcher.

The additional V-A's will enable Intelsat to cope with the exploding demand for international telecommunications, particularly in the heavy-volume Atlantic and Indian Ocean zones, until Intelsat VI satellites, with up to 40,000 telephone-call capacity, become available in 1986.

MARITIME TRIALS

A Royal Navy survey vessel, *HMS Herald*, sailed for the Arabian Sea on 2 September 1981 to carry out a programme of sea-trials designed to evaluate the performance of shipborne satellite telecommunications terminals at very low satellite elevation angles. The terminal used for these trials was Arion, provided by Marconi Communication Systems Limited.

The planned coverage of the world by maritime satellites, which are geostationary, is intended to provide the maximum coverage for ships at sea. However, in addition to the two polar regions, there will be an area off the west coast of South America which is likely to suffer problems as it will be at the extremes of line-of-sight for both the Pacific and the Atlantic main path satellites.

The programme in which the Arion terminal took part was designed to create, artificially, the same kind of problems that ships using the Inmarsat system are likely to encounter in these troublesome areas. Normally ships in the arabian Gulf would use the Indian Ocean satellite, but *HMS Herald*, was to access the Atlantic main path Marecs A, due to be launched in December 1981 by Ariane. This was to create very low angles of elevation above the horizon, typically of less than 5 degrees, which presents a number of propogation problems.

By use of a set of voice-tapes provided by British Telecom, a scientist from the Royal Aeronautical Establishment aboard *HMS* Herald was to establish a series of recordings and measurements for later subjective quality analysis. Additionally, British Telecom made Goonhilly 5, the United Kingdom's first maritime coast station, available for the programme.

DIRECT BROADCAST SATELLITES

Direct broadcast satellites will become more familiar to the general public by the middle of this decade. They will be powerful craft able to beam TV broadcasts (among other communications) down to aerials about 4ft across on people's homes, where the TV set will unscramble the signals for conversion into pictures.

ATS 6 demonstrated the techniques in experiments with Indian villages in the mid-1970's and Japan launched its BSE satellite to cover most of its islands with two TV channels. Canada's CTS satellite can be picked up by users with small aerials operating at 14/11GHz.

Theo Pirard of the Space Information Centre in Belgium has produced a list for *Space Communications* showing the status of DBS projects as of July 1981. Some are already under development, while others are still under study.

DIRECT BROADCAST SATELLITES

Australia
Domestic system using multipurpose satellites and 1.5m stations. For 1985-86.

Austria
Under study for 1986(?), a joint Austrian-Swiss project.

Canada
Anik B operational from 1978, Anik C under development for 1982. Domestic system TV broadcasts to 1.2 m stations.

Europe/Italy
L-Sat for launch in 1985(?). An experimental craft, will include Italian TV broadcasts.

France
TDF-1 under development for 1984-85. Preoperational craft developed in cooperation with Germany (see TV-Sat).

Germany
TV-Sat under development for 1984-85. Preoperational craft developed in cooperation with Germany (see TV-Sat).

Germany
TV-Sat under development for 1984-85, using same platform as French TDF-1.

India
Insat I under development for 1982-83. Two craft for multiple uses, particularly TV to 3.6 m stations at 2.5 GHz.

Japan
BS-2 under development for 1983-85. Two for operational services.

Luxembourg
Possible for 1985, an operational craft for European TV.

Scandinavia
Nordsat under study for 1986(?). Presently delayed pending political approval for Nordic cooperation.

Sweden
Tele-X under study for 1986(?). Pre-operational, for multiple experiments.

Switzerland
Tel-Sat possible for 1984-85, for European TV.

UK
SBC (Satellite Broadcasting) under study for 1985-86(?), first British applicant as DBS operator.
STV (Satellite Television) under study for 1986(?), private interest in British DBS with ECS spacecraft.

USA
Comsat/STC, in preparation for 1985-86, for pay-TV programmes.
DBS Corporation under study for 1986(?), proposal for leasing system.
Hubbard Broadcasting under study for 1986(?), DBS for TV stations.
RCA Americom/DBS under study for 1986-87(?), possible DBS applicant.

USSR
Ekran, first launched in 1976. Up to July 1981 seven satellites launched to beam TV to Central Siberia.

SALYUT 6 MISSION REPORT : Part 9

THE FLIGHT OF SOYUZ T-3

By Neville Kidger

Preparations For A New Start

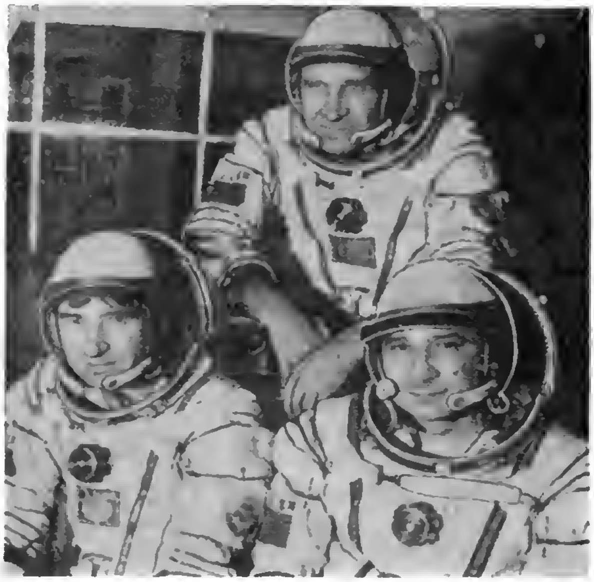
During Salyut's autonomous flight, FCC specialists constantly monitored the functional states of the station's ODU, power supply and thermoregulating system. On 16 November, for the first time ever automatically, Progress 11, still docked to the aft port, refuelled the ODU. On 18 November Progress 11's SKDU was used to adjust the orbit of the complex. Following the burn the orbital parameters were: 315 x 299 km; period 90.5 mins; inclination 51.6°.

Also on the 18th the Paris communist newspaper *L'Humanite* carried an interview with Georgi Beregovoi in which the head of the Gagarin Training Centre said that a three-man crew would soon fly to Salyut 6 to effect repairs and assess the state of its sysems with a view to the possible reuse of the station for a long flight.

The first Soviet three man crew for 9½ years consisted of rookie Commander (CDR) Lt-Col Leonid Kizim, 39 at the time of the flight (he joined the cosmonaut corps in 1965 and is one of the "career cosmonauts" who learned to fly advanced planes after being selected). He was reserve DCR for the Soyuz T-2 flight. The Flight Engineer (FE) was veteran cosmonaut Oleg Makarov, 47, who flew into space aboard Soyuz 12 and 27 as well as taking part in the Soyuz 18 "April 5 Anomoly" launch failures (which lasted for 291s, according to Makarov). The third cosmonaut was Research Engineer (RE) Gennady Stekalov, 40, who like Makarov, graduated from the Bauman Technical School and was an apprentice coppersmith at the time the first AES was being constructed. Strekalov joined the cosmonaut corps in 1973, along with Ryumin and Aksenov. He was Aksenov's reserve on the Soyuz 22 flight. All three began working with the Soyuz T design while it was still in the blueprint stage.

The flight plan for Soyuz T-3 envisaged 13 days of work in space, including tasks connected with testing the Soyuz T-3 craft and conducting complicated repairs to the Salyut 6 laboratory.

The Soviets say that crew composition on future flights of the Soyuz T design will be variable. The third cosmonaut has no piloting function and his place can be taken by extra equipment. While in autonomous flight Soyuz T is pressurised by pure oxygen in contrast to the oxygen/nitrogen atmosphere on the Soyuz ships.



Soyuz T-3 crew. Left to right: Strekalov, Makarov and Kizim.
Novosti

Soyuz T-3 In Flight

Soyuz T-3 was launched at 1418 (all times GMT) on 27 November 1980. Once in space, the cosmonauts remained harnessed to their seats until the hermeticity of the compartments was confirmed. CDR Kizim, call sign Mayak-1, reported that the crew felt well.

By midnight on the 27th following the standard rendezvous sequence, Soyuz T-3 was in an aproach trajectory with Salyut 6/Progress 11. At 5 km from the complex, Kizim handed control of the docking over to the Argon computer, or Mayak-4 as FCC often referred to it (referencing its value as akin to that of a fourth member of the crew). The software problems experienced by the Jupiters on Soyuz T-2's docking had been successfully resolved and, at 1554, exactly on schedule, the ship

IN TRAINING

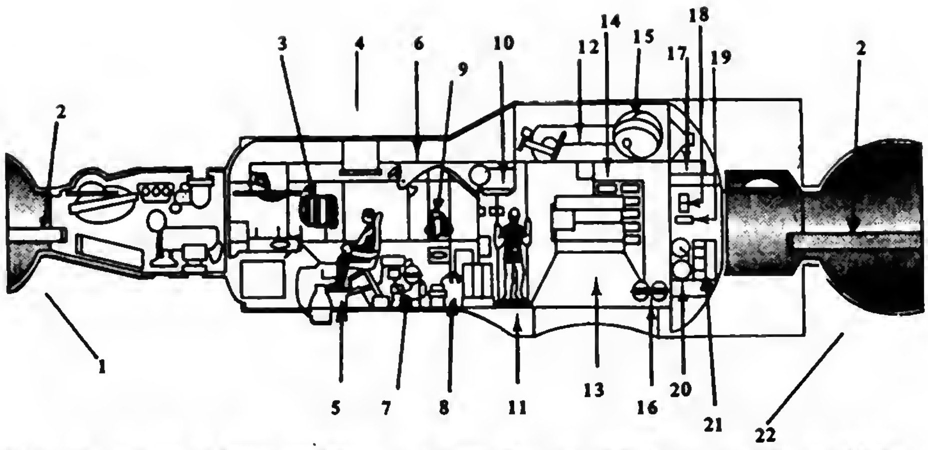
Two French cosmonaut candidates are in training for a joint Soviet-French mission to Salyut 7. Jean-Loup Chretien (right) and Patrick Baudry (centre) are seen here in a Salyut mockup at the Gagarin training centre with General Beregevoi.

The Soviets are clearly interested in developing a permanent space station. Spacecraft designer Konstatin Feoktistov has said, "....a space station will accommodate enough people to man a whole scientific laboratory. Working aboard the station, they will release space observatories and satellites into space and insert them into desired orbital paths."

Intercosmos/CNES

Major Salyut 6 features:

1. Soyuz ferry vehicle
1. air hoses
3. air regeneration device location
4. solar panel orientation device
5. central control post
6. veloergometer
7. drinking water dispenser
8. vacuum chamber
9. water regeneration device location
10. shower
11. running track
12. bed
13. BST-1M submillimeter telescope
14. food lockers
15. ShK number 1 airlock



16. drinking water storage 17. storage for personal hygiene equipment and underwear 18. mirror 19. electric toothbrush storage 20. liquid waste collection device 21. hygiene napkins 22. Progress cargo ship (of Soyuz)

N. Kidger

docked with the front docking port of Salyut 6. After equalisation of pressure between the vehicles (possibly involving dumping of the Soyuz T-3 oxygen atmosphere overboard and bleeding in the atmosphere from Salyut) Makarov opened the internal hatches and floated into the station.

The first thing Makarov found was a bundle of small loaves and some salt left for them by the Dniepers. Makarov thanked Popov and Ryumin for their genuine and welcome surprise. Both crews would converse together at length during the flight.

The first work activities, as always, involved turning the station over from autonomous to manual control. The life-support systems were made fully operational (certain functions are begun automatically by FCC before the launch of a crew). In addition, the cosmonauts activated the Oasis and Svetoblok biological installations to conduct some of the ten experiments planned during the short flight. Salyut was put into a gravity stabilised mode to conserve fuel during the flight.

Working Aboard Salyut

At first the Mayaks found adaptation to weightlessness difficult because of the heavy work load forced on them during the short flight. To aid their adaptation, FCC physicians added physical exercises to the crew's work programme on the second day aboard Salyut. The cosmonauts were cautious in conducting their tasks for the first days in order to avoid any sickness. Parameters of the microclimate inside Salyut were: pressure 780 mm; temperature 21°. A prime task for the cosmonauts early in their stay on Salyut was to take air samples from all over the station in the experiment called Microclimate. The samples would show if air was stagnating in any sections of the station because of slow movement by the airflow from the 20 ventilators. The temperature, humidity and other factors of the sampled air would be determined on Earth.

During the flight, and at all stages of their scheduled repair work, the Mayaks consulted Popov and Ryumin, who were resting at Kislovodsk, *via* a specially established radio link. The repair work occupied the Mayaks so much that FCC directors cancelled one of the crew's free days and two TV broadcasts. More importantly, the cosmonauts were not able to carry out their planned exercises.

FCC specialists stated that the repair work was vital for Salyut's future. Launching Soyuz T-3 and conducting the repairs was costly, the Soviets said, but nowhere near as costly as launching a new station.

The largest, and most vital, repair the Mayaks conducted involved the replacement of a 4-pump hydro-pump block which circulated fluid (akin to anti-freeze) through pipes located all over the station's bulkhead to provide temperature regulation. After 3 years of continuous use the hydro-pump had given out. Repair of this vital system was complicated by the fact that designers had never really anticipated utilising Salyut 6 for longer than two years and so designed the pump to be permanent. Therefore, to get to the hydro-pump it was necessary to saw off one of the metal supports. The replacement pump contained the liquid coolant and the cosmonauts had to ensure, with immense care, that none of the liquid was spilt (there would be no chance of disposing of a sphere of coolant floating around the station in the same way Popov and Ryumin had disposed of a sphere of 2½ litres of water they spilt one day - both men approached the globule from different sides and drank it away!) The pipes of the system had to be decompressed before the pump was installed, prompting FCC to advise the crew to be careful. Kizim radioed down, "Don't worry, we're experienced drivers."

- Faults in the electricity supply commutator were diagnosed from telemetry during autonomous flight. The Mayaks measured the electrical flow in the circuits and determined the fault. FCC advised them on rectification methods.
- A faulty electronics unit in the telemetry system was repaired by partially dismantling the device and replacing certain elements.
- A faulty ODU refuelling system compressor transformer was replaced.
- A new set of programme-timing devices, used to control station systems, was installed.
- The structural stability of the complex was tested in the Amplituda experiment. Following metronome signals one crewman jumped up and down on the running track using different rhythms. A micro-acceleration transducer, delivered by Progress 11, telemetered the effects to FCC.

The two engineers, Makarov and Strekalov, inspected every corner of the complex and prepared a detailed assessment of the condition of all the systems and external elements. They searched for cracks in the portholes; the Soviets note that no suitable replacement has yet been found to replace porthole glass.

Scientific Work

The Mayaks had a short programme of scientific work to conduct during the flight, including a new and potentially

important experiment concerning development of a holographic recording technique.

In the Soviet/Cuban Hologram experiment, conducted on 2 December, the Mayaks tested a 5 kg holgraphic camera. The camera, originally designed for the Soviet Cuban Soyuz 38 flight, had not been ready for flight when cosmonauts Romanenko and Tamayo Mendez were launched. The portable camera used a helium-neon laser optical system and registering systems developed in Leningrad. The holographic technique allows full-volume measurements of the subject. Ground-based studies made with holographic techniques have included study of plasmas, tyre quality control, turbine blade quality control and art.

Holography is sensitive to vibration; the slightest shift of the subject can make the whole holograph useless. On Earth the optics are mounted on massive, multi-tonne, bases while the laser system for Salyut 6 was designed to be immune from vibration. The device has been used to make a hologram of a moving train.

In order to assess the holographic camera's potential and capabilities, the dissolution processes of a single salt crystal in a container was used. At various intervals during dissolution the Mayaks obtained a hologram of the crystal. Study of the returned holograms should allow scientists to see how the density of the crystal is distributed through dissolution without convective flows. If the system works, later studies with holographic cameras will include monitoring of the portholes of stations and gas efflux from attitude control nozzles.

Other scientific activities to occupy the Mayaks included a 3-day Splav smelting experiment to obtain a KRT crystal (See Part 8) and three separate experiments to obtain samples of gallium bismuth on the Kristall furnace. Medical experiments included measurement of the blood flow during exercise on the ergometer on Oleg Makarov.

Return to Earth

On 8 December the Mayaks began packing the results of their work into the descent module of Soyuz T-3. Progress 11's SKDU was used to correct the complex's orbit on the same day. The resultant parameters were: 370 x 290 km; period 90.8 mins; inclination 51.6°. The next day, Soyuz's systems were checked and the rest of the results stowed. At 1023, Progress 11 was commanded to undock from the complex. All was now ready for them to return home.

At 0610 on 10 December Soyuz T-3 was undocked from Salyut 6 and retofired over the South Atlantic to fly a nominal re-entry (some reports suggest the descent was fully automatic) to land some 130 km East of Dzezkazgan at 0926.

Medical checks at the landing site showed that, because they were unable to carry out the full programme of exercises, cosmonauts Kizim and Strekalov suffered from a certain amount of tension. Makarov, in contrast, was in better condition probably cause of experience gained from his previous flights.

At 1400 on 11 December the Progress 11 SKDU was ignited for the last time and the cargo spaceship was brought out of orbit to burn up over the Pacific ocean away from the shipping lanes. Progress 11 had been attached to Salyut 6 for 70 days, the longest ever flight by a Progress ship; earlier Soviet descriptions of Progress said that it had a maximum orbital duration attached to Salyut of about 30 days.

The Mayaks collected their State and Party awards from L.I. Brezhnev in the Kremlin on 24 December. Summing up the Soviety Union's year in space the Soviet leader said that never before had the USSR had such a full year in space technology. Six crews had flown into space, the duration of a flight had been extended to 185 days, three international crews had flown and the new Soyuz T ship had been verified to replace the existing system.

By 0900 on 29 December, 39 months after its launch, Salyut 6 was in an orbit with a height of 349 x 308 km; period 91 mins; inclination 51.6°.

IMPORTANT NOTE: Owing to a misunderstanding of the Soviet name for the Soyuz-T computer, the writer incorrectly assigned the initials ABKK to it. An article by N. Rukavishnikov in Zemlya i Vsellnaya (no. 1/81) calls the computer an Onboard Numerical Calculation Complex - Soviet acronym BTsVK. This acronym will be used in all future reports. The writer regrets the error and assures readers that all other acronyms quoted are correct.

References and notes as Part 1. The list will be repeated in the next part of the report.

THE COSMONAUTS - Part 22

By Gordon R. Hooper

Lt. Colonel Leonid Ivanovich Popov

Leonid Popov was born on 31 August 1945 in the town of Alexandria, Kirovograd Region. His father, Ivan Alexeiyevich Popov, was a crop farmer, and chairman of a co-operative farm. He advised Popov to go to an agricultural academy after school, but instead he went to work in an electrical engineering plant for two years where he mastered the trades of fitter and electrician. He also married and had a daughter.

Then, without a word to his family, he went to an air school to sit the entrance exams. He subsequently graduated from the Chernigov Higher Military Aviation College for Pilots in 1968 and then served as a fighter pilot in the Soviet Air Force. He became an experienced pilot, accumulating 1200 hours in the air. He had a close escape on one occasion when his plane's engine stalled and he had to bale out.

Popov was selected for cosmonaut training in 1970 at the age of 25, and his training was supervised by Volynov. He joined the CPSU in 1971, and graduated from the Yuri Gagarin Air Force Academy in 1976, while still undergoing training at the Yuri Gagarin Cosmonauts Training Centre in Star Town. His first assignment was as back-up to Valery Bykovsky, the commander of Soyuz 22. He then served as back-up to Vladimir Lyakhov, the commander of Soyuz 32.

His first spaceflight came as commander of the Soyuz 35 mission, launched on 9 April 1980. He had originally trained with Valentin Lebedev for the mission but, following an injury, Lebedev was replaced by Valery Ryumin. During their long stay aboard Salyut 6 they played host to the visiting cosmonauts from Hungary Vietnam and Cuba.

Ryumin and Popov returned to Earth on 11 October 1980, having spent 183 days 20 hrs and 12 mins in space - thus setting a new manned spaceflight record. Upon his return, Popov was awarded the title of Hero of the Soviet Union, with Gold Star Medal and Order of Lenin. He was also awarded the title of Hero of the Republic of Cuba, with Gold Star Medal and the Order of Playa-Giron.

Popov was the 46th Soviet cosmonaut.

Lt. Colonel Leonid Denisovich Kizim

Leonid Kizim was born on 5 August 1941 in the city of Krasny Liman in the Donetsk Region of the Ukraine. His parents both worked on the railway, although they are now retired. Kizim set his heart on becoming a pilot and, after finishing secondary school, he enrolled at the Chernigov Lenin Komsomol Higher Military School for Pilots. He graduated in 1963 and then served in the Soviet Air Force in the Caucasus.

He was selected as a cosmonaut in 1965, and joined the CPSU in 1966. Following his selection, he learned to fly several types of aircraft and was awarded the qualification of test-pilot 3rd class. He is also a military pilot 1st class.

Kizim was assigned to the special group of cosmonauts which began training in 1975 for Soyuz/Salyut flights and which also included Popov, Malyshev and Romanenko. He graduated from the Yuri Gagarin Air Force Academy in 1975, through a correspondence course. His first assignment was as back-up to Yuri Malyshev, the commander of Soyuz T-2, launched on 5 June 1980.

His first spaceflight came as commander of Soyuz T-3, launched on 27 November 1980, in the first test-flight of the three-seat version of the Soyuz spacecraft. The crew docked with the orbiting Salyut 6 space-station and spent 10 days carrying out repairs to the ageing craft before returning to Earth after a flight lasting 12 days 19 hrs and 8 mins.

Upon his return, Kizim was awarded the title of Hero of the Soviet Union. According to Soviet reports, he was actively involved in the designing and ground testing of the Soyuz T spacecraft.

Kizim was the 48th Soviet cosmonaut.

Gennady Mikhailovich Strekalov

Gennady Strekalov was born on 28 October 1940, in the town of Mytischchi, near Moscow. His father was killed in action in 1945 during the liberation of Poland. Strekalov finished school and then worked for two years in a factory. As an apprentice coppersmith he was present for the fabrication of Sputnik 1. He then entered the Bauman Higher Technical School and upon graduation in 1965 went to work in Sergei Korolyov's design bureau. He earned the reputation of being an innovative and competent engineer, and worked on the design of new space vehicles, including the Soyuz spacecraft. He proved to be a good designer and has had two inventions patented. He joined the CPSU in 1972.

He was slected as a cosmonaut in 1973 and his first assignment as as back-up to Vladimir Aksyonov, the flight-engineer of Soyuz 22 launched on 15 September 1976.

His first spaceflight came as research-cosmonaut of Soyuz T-3, launched on 27 November 1980, in the first test flight of the three man version of the Soyuz T spacecraft. The role Strekalov played - that of research cosmonaut - was the new position afforded by the third seat.

Upon his return, Strekalov was awarded the title of Hero of the Soviet Union. He is, according to Soviet sources, one of the engineers responsible for the design and ground testing of the Soyuz T spacecraft, and for the development of the Salyut stations.

Strekalov was the 49th Soviet cosmonaut.

1982 SUBSCRIPTION FEES

In spite of a 10% inflation rise the 1982 membership rates are the same as last year, with even a slight reduction for members who remit in US dollars, arising from improved exchange rates.

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(h) Remittances from Europe can be made by GIRO: this is the easiest and cheapest method of transferring funds. Our GIRO account number is 53 330 4008.

SATELLITE DIGEST — 150

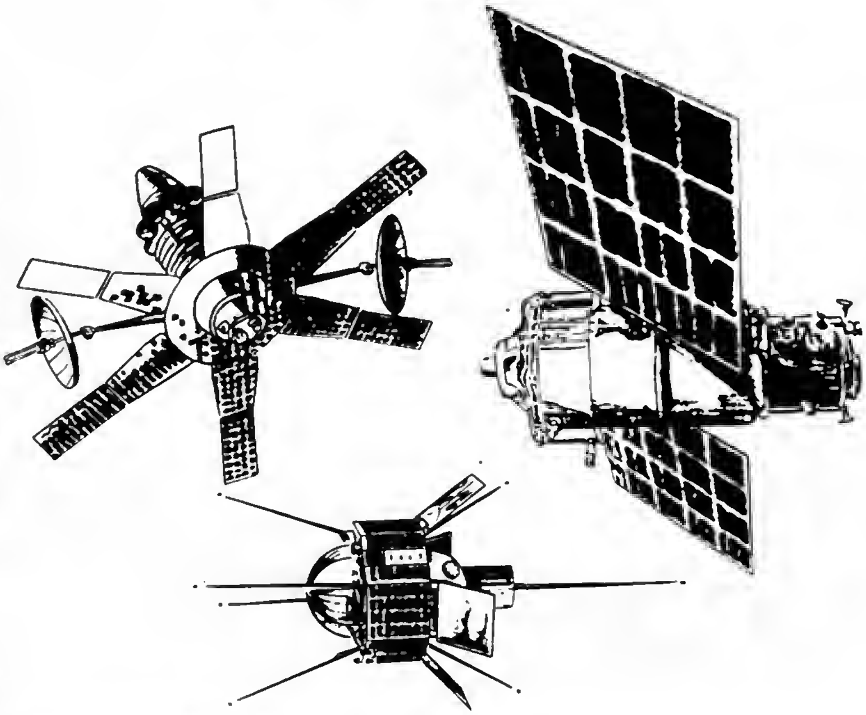
A monthly listing of satellite and spacecraft launches, compiled from open sources.

The heading to each launch gives the name of the satellite or craft, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes, except where marked with an asterisk, where the time is to the precise minute as announced by the launching agency.

Robert D. Christy
Continued from the November 1981 issue

MOLNIYA-1 (50) 1981-60A, 12556

Launched: 1744, 24 Jun 1981 from Plesetsk by A-2-e.
Spacecraft data: The Molniya-1 is a cylindrical body housing instrumentation and the payload, surmounted by a conical motor section. Power is provided by a 'windmill' of six solar panels. Overall length is 3.6m, the diameter 1.6m and the mass about 1800 kg.
Mission: Replacement or backup for Molniya-1 (42), 1978-80A. The satellite helps to operate long distance telephone and telegraphic communications and broadcasts central television programmes via the Orbita system to remote areas of the Soviet Union.
Orbit: Initially a low, parking orbit and then injected into a highly elliptical orbit of 617 × 40640 km, 736.13 min at 62.79 deg inclination. Later manoeuvred to 614 × 39742 km, 717.80 min, 62.85 deg inclination to give daily repetition of the ground track.



Satellites (left to right) of the Molniya, Cosmos and Meteor classes.
Drawing by Richard Escarcega

EKRAN 7 1981-61A, 12564

Launched: 2356, 25 Jun 1981 from Tyuratam by D-1-E + apogee motor.
Spacecraft data: A cylinder with a pair of boom mounted solar panels and a rectangular transmitting array. Length 5m, diameter 2m and mass (in geostationary orbit) around 2000 kg.
Mission: To transmit programmes of Central Television to collective receiving stations in remote areas.
Orbit: Initially a low parking orbit at 51.6 degrees inclination, then to an elliptical transfer orbit at 47 deg inclination prior to injection into near stationary, equatorial orbit. Later stabilised above longitude 99 deg east (Stratsionar T).

COSMOS 1279 1981-62A, 12571

Launched: 0929, 1 Jul 1981 from Tyuratam by A-2.
Spacecraft data: Possibly based on Vostok manned spacecraft with spherical re-entry module, instrument unit and a cylindrical, supplementary payload at the forward end. Length about 6m, max diameter about 2.4m, mass around 6000 kg.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: Initially 210 x 362 km, 90.28 min, 70.38 deg inclination. Manoeuvered on second day to 360 × 418 km, 92.37 min, 70.41 deg. Orbit maintained by small thrusts to ensure constant spacing between equivalent ground tracks on successive days.

COSMOS 1280 1981-63A, 12577

Launched: 0709, 2 July 1981 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1279.
Mission: Possibly military photo-reconnaissance, part or all of the payload was an Earth resources survey package. Recovered after 13 days.
Orbit: Injected into 256 × 273 km, 89.87 min, 82.31 deg inclination orbit.

COSMOS 1281 1981-64A, 12583

Launched: 1230, 7 Jul 1981 from Plesetsk by A-2
Spacecraft data: As Cosmos 1279.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 357 × 414 km, 92.30 min, 72.84 deg, maintained by small thrusts to ensure constant spacing between equivalent ground tracks on successive days.

METEOR PRIRODA 1981-65A, 12585

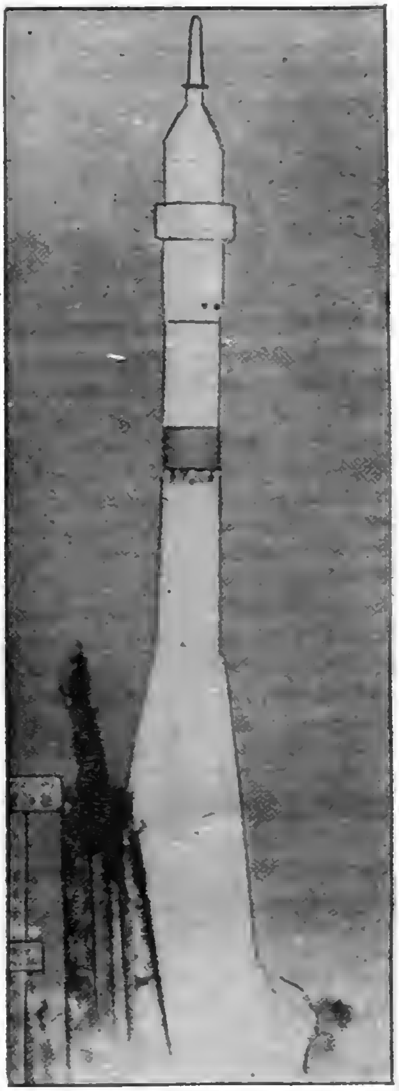
Launched: 0520, 10 Jul 1981 from Tyuratam by A-1.
Spacecraft data: Cylindrical body with two, Sun seeking solar panels, length about 5m, diameter abut 1.5m, mass about 2200 kg.
Mission: Earth resources and meteorology. The satellite carries multispectral television scanning equipment and a three channel microwave radiometer to produce pictures. Aditionally, equipment supplied by Bulgaria as part of the 'Bulgaria 1300' programme includes a multi channel spectrometer working in visible and near infra-red light, a single channel radiometer, and a data recording and processing computer. To ensure coverage of specific target areas, a small manoeuvring engine is also carried.
Orbit: 609 × 679 km, 97.55 min. 97.93 deg inclination, Sun synchronous.

ISKRA 1981-65B, 12587

Launched: Piggyback with Meteor Priroda.
Spacecraft data: Details not available.
Mission: Scientific and technical experiments, built by the student design office of the Moscow Aviation Institute.
Orbit: 636 × 661 km, 97.75 min, 97.98 deg inclination.

COSMOS 1282 1981-66A, 12588

Launched: 1300, 15 July 1981 from Tyuratam by A-2.
Spacecraft data: As Cosmos 1279.
Mission: Military photo-reconnaissance, recovered after 30 days.
Orbit: Initially 172 × 334 km, 89.58 min, 64.90 deg inclination subsequently modified by maneouvres to cover specific targets.



About 700 A-2 launchers have been used, with more than 100 of them in the A-2-e version. This is hè ASTP launch of 1975.
NASA

COSMOS 1283 1981-67A, 12598

Launched: 0759, 17 Jul 1981 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1279.
Mission: As Cosmos 1280. Recovered after 14 days.
Orbit: Initially 181 × 260 km, 88.95 min, 82.31 deg. manoeuvred on second day to 325 × 371 km, 91.55 min, 82.35 deg. Orbit maintained by small thrusts to ensure constant spacing between equivalent ground tracks on successive days.

COSMOS 1284 1981-68A, 12614

Launched: 1154, 29 Jul 1981 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1279.
Mission: As Cosmos 1280. Recovered after 14 days.
Orbit: Initially 192 × 229 km, 88.75 min, 82.33 deg, then manoeuvred to 325 × 370 km, 91.53 min, 82.34 deg. Orbit maintained by small thrusts to ensure constant spacing between equivalent ground tracks on successive days.

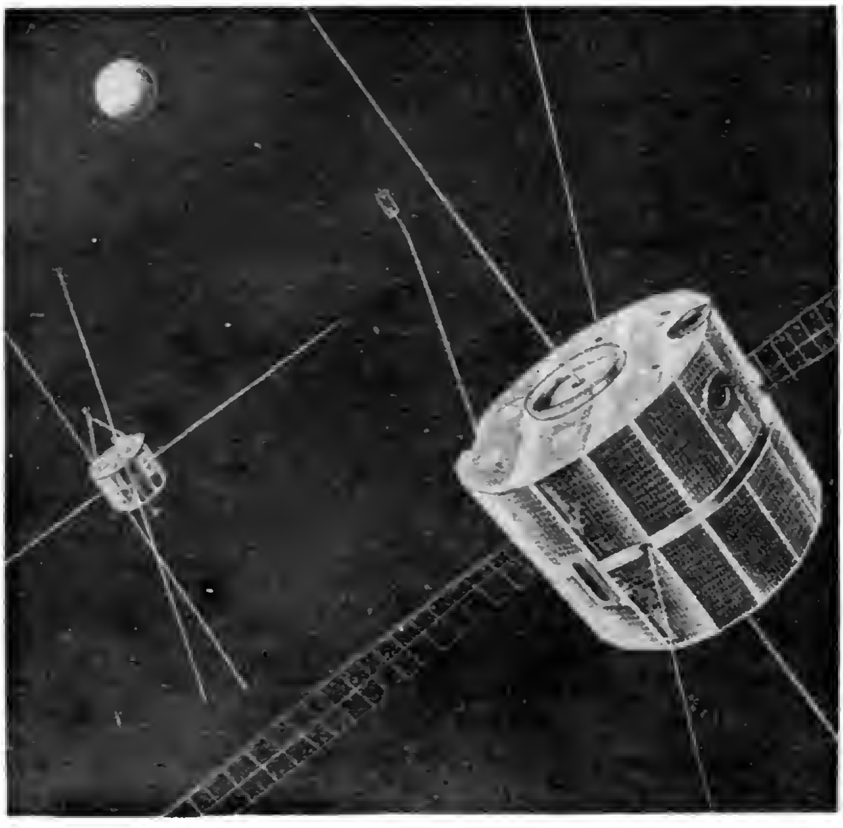
RADUGA 9 1981-69A, 12618

Launched: 2138, 30 July 1981 from Tyuratam by D-1-E + apogee motor.
Spacecraft data: Cylinder with two solar panels and a transmitting and receiving array. Length 5m, diameter 2m, mass (in goestationary orbit) around 2000 kg.
Mission: To provide twenty-four hour telephone and telegraphic communication, and to broadcast colour and monochrome television programmes from Central Television.
Orbit: Initially, a low, parking orbit at 51.6 degrees inclination, then to an elliptical transfer orbit at 47 deg inclination prior to injection into near stationary, equatorial orbit. Later stabilised above longitutde 35 deg east (Statsionar 2).

DYNAMICS EXPLORERS 1 & 2 1981-70A and B, 12624 and 12625

Launched: 0955*, 3 Aug 1981 from the Western Space and Missile Centre by Delta 3913.
Spacecraft data: Both craft were built by RCA Astro-Electronics for NASA and are 16 sided polygonal cylinders, covered in solar cells. Each is 1.35 m in diameter and 1.14 m in height. DYNAMICS EXPLORER 1 has a mass of 403 kg (including 105 kg of instruments) and DYNAMICS EXPLORER 2 is 415 kg (incl 111 kg of instruments). Sensors are directly attached to the body or boom mounted.
Mission: To study the coupling of energy, electric fields and currents, and plasmas within the magnetosphere, the ionosphere and the atmosphere. Simultaneous measurements are made from two different heights. DYNAMIC EXPLORER 1 carries a fluxgate magnetometer, a plasma wave detector, a spin scan auroral imager (or radiometer), a retarding ion mass spectrometer, an ion detector and an energetic ion mass spectrometer. DYNAMICS EXPLORER 2 carries another fluxgate magnetometer, a vector electric field detector, a neutral atmosphere composition spectrometer, a wind and temperature spectrometer, a Fabry-Perot interferometer, an ion drift meter and a retarding potential analyser.
Orbits: DYNAMICS EXPLORER 1—558 × 23925 km, 410.92 min, 89.91 deg. DYNAMICS EXPLORER 2—298 × 996 km, 97.66 min, 89.99 deg.

This is the first of our new-look *Satellite Digests*. The format allows the addition of photographs and diagrams much more easily than the full page tabulation previously used. We welcome readers' opinions.



The Dynamics Explorers were launched from Vandenberg on 3 August in the first Delta 3900 firing from that site. The second stage was short of 250 lb of propellant owing to a ground error, and the resulting orbits were not as intended.
NASA

THE NOAA ENVIRONMENT SATELLITES

By Nicholas Steggall

Introduction

The Tiros N/NOAA A-G series of spacecraft is the new generation of operation environmental monitoring satellites to be launched by the US. They provide scientists (including Meteorologists, Oceanographers and Hydrographers) with information about much of the Earth's environment, the atmosphere, weather conditions, sea ice, water etc. Intended to work in pairs, Tiros N will observe every part of the Earth twice daily. Although there have so far been only two operational - Tiros N and NOAA 6 (formerly NOAA A) - it is planned to launch six more. NOAA B/NOAA 7 failed to achieve orbit on 29 May 1980 so Tiro N was to be kept in full service until the next spacecraft, NOAA C, was launched on 23 June and not maintained on a stand-by status as was intended.

The objectives of the Tiros N series of spacecraft include the collection of environmental data for use in the National Operational Environmental Satellite System (NOESS) and also to support the Global Weather Experiment. More specific objectives include the provision of improved methods for obtaining quantative environmental data and improved data handling capabilities *via:*

- Higher resolution day and night cloud cover observation on a local and global scale
- High resolution observations of sea surface temperatures
- Improved observations of vertical temperature and water vapour profiles in the troposphere and lower stratosphere on a global basis
- Observations of vertical temperature profiles in the middle and upper stratosphere on a global basis
- Operational flight of a high-capacity data collection-relay and platform location system
- Observations of electron and proton flux densities and total particle energy densities in the near-Earth space environment.

TIROS N/NOAA A/G STATISTICS

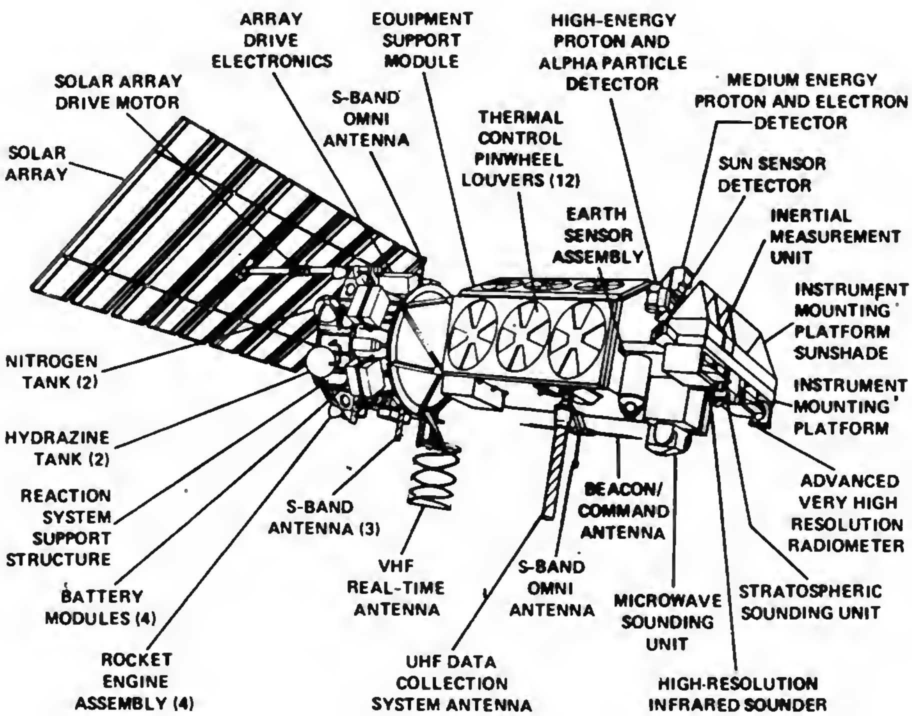
Height	3.71 m (146 in)
Diameter	1.88 m (74 in)
Lift-off weight	1421 kg (3127 lb)
Orbital weight	736 kg (1620 lb)
Payload weight	194 kg (427 lb)
Payload weight reserved for growth	36.4 kg (80 lb)
Solar Array size	2.37m x 4.91m. 7.8 ft x 16.1 ft

Funding

This programme is a co-operative effort between NASA, the United Kingdom and France. The development and launch of Tiros N, including the first flight satellite, has been funded by NASA while subsequent satellites are to be procured and launched by NASA using NOAA funds. The operational ground facilities, which include the Command and Data Aquisiton (CDA) stations, the Satellite Control Center and the data processing facilities (with the exception of the Data Collection System processing facility) are procured, funded and operated by NOAA. The Meteorological Office and the Ministry of Defence of the United Kingdom provide a Stratospheric Sounding Unit, one of three sounding instruments for each satellite. The Centre National d'Etudes Spatiale (CNES) of France provides the Data Collection System instrument together with the facilities necessary to process and make available the data obtained from this system. Ground facilities for the reception of sounder data during the blind orbit periods is provided by the Centre d'Etudes de la Meteologie Spatiale (CEMES) of France.

Spacecraft Description

In order to cut development costs and apply proven



technology, the Tiros N series have incorporated technology drawn from the Nimbus programme, as well as being based on the spacecraft bus of the US Air Force's Block 5D metsats. It is capable of meeting any mission requirement but at the same time retains a growth capacity in payload of 25%.

Built and designed by RCA Astro Electronics, the structure and thermal designs are of modular construction. They consist of four major elements; the reaction control equipment support structure (RSS), the equipment support module (ESM), the instrumental mounting platform (IMP) and the solar array. In order to interface Tiros with the launch payload adapter, a transition ring is required for the base of the spacecraft. The solar array is mounted on a hinged boom attached to the RSS for deployment at 90° to the orbital track. In order that the Sun can be followed, the array rotates around the boom axis.

Positioned at the centre of the top ESM panel by a three point mount is that its broad face is perpendicular to the local vertical, the IMP is the primary mounting surface for the Earth viewing payload. The ESM upper structure derives from a hexagonal prism with one apex removed. Antenna and instruments are mounted on the Earth-facing side of this module, while electronic equipment that does not require this is positioned on the internal sides of the six panels. The lower portion of the ESM structure connects the ESM to the RSS at six points while enclosing the upper part of the second stage solid engine.

In order to keep the spacecraft in a stable thermal condition, the thermal control subsystem consists of two components; the passive control components of blankets, finishes, insulators, shades and the active control components of pinwheel and vane louvres, heaters and control electronics.

The communications links for Tiros are:

- A realtime S-band digital link (1698-1701 MHz) for a continuous transmission of high resolution video (HRPT) to local ground stations.
- A realtime VHF link (137.5 or 137.62 MHz) for continuous transmission of medium-resolution video (APT) to local ground stations.
- An S-band digital playback link (1698, 1702.5 or 1707 MHz) for recovery of CDA stations of global recorded data or high resolution AVHRR recorded data.
- A beacon downlink (136.77 or 137.77 MHz) for realtime transmission of telemetry and low rate sensor data.
- A command uplink (148.56 MHz).
- A UHF data collection uplink (401.65 MHz).
- An S-band digital-playback link (1698, 1702.5 or 1707 MHz) for recovery of recorded TIP data by a European ground station.
- AN S-band digital ascent telemetry link (1702.5 Mhz).

The power supply consists of a boost-discharge direct-energy-transfer system of +28V primary distributed voltage. An 11.6m² (125 ft²) solar array with single axis orientation provides 420 W orbit average local capicity. The Sun angle range of the array is 0 to 68° powering two 30 amphere hour batteries for the two years of the intended missions.

Instrumentation

Predecessor NOAA instruments have been flown experimentally on Nimbus (sounders), ITOS (Space Environment Monitor) and EOLE (Data Collection System). To meet the scientific and technical requirements of the mission, such as orbital constraints, spacecraft bus, etc, these instruments were redesigned to improve upon the quality of the data.

The primary environmental sensors for the satellite series are:

Orbital Parameters

Orbital altitude	833 km (516 mi*1)/870 km (540 mi*2)
Type	near polar, Sun synchronous
Inclination	98.739°*1/98.899°*2
Period	101.6 minutes*1/102.37 minutes*2

*1 Tiros N/NOAA A. *2 NOAA B

1. A Tiros Operational Vertical Sounder (TOVS), a three-instrument system consisting of:

   a) The High Resolution Infrared Radiation Sounder, a 20 channel instrument to make measurements primarily in the infrared region of the spectrum, including the longwave (15 m) and shortwave (4.3 m). It is designed to provide data that will permit the calculation of a temperature profile from the surface to 10 mb, water vapour content in three layers in the atmosphere and the total ozone content. The design is based on the HIRS instrument flown on the Nimbus 6 satellite.

   b) The Stratospheric Soiunding Unit (SSU) employs a selective absorption technique in order to make measurements in three channels.

   c) The Microwave Sounding Unit (MSU) is a 4 channel, step scanning radiometer using the infrared region.

   The aim of this atmospheric sounding is to compare the profiles obtained globally in order to gain an accuracy of 1°C in temperature and 20% in moisture vapour content.

2. The Advanced Very High Resolution Radiometer (AVHRR) is a 4 channel scanning radiometer (5 channels are to be used on later spacecraft in the series) sensitive in the visible, near infrared and infrared window regions. Data is used to provide day and night sea surface temperature, ice, snow and cloud information to users.

3. The Space Environment Monitor (SEM) is an extension of the solar proton monitor (SPM) from the ITOS satellites. The continuous measurement of the proton, alpha and electron flux activity, spectrum and total energy disposition in the Earth's upper atmosphere is followed by SEM.

4. The Data Collection System (DCS) is a random access system used to acquire data from fixed and free floating platforms. This data is also included in HRPT and beacon transmissions and can be obtained from up to 2,000 platforms per day. Platform location is, therefore, possible from ground processing of the Doppler measurements of carrier frequencies.

Acknowledgments

Acknowledgments must go to the following in the preparation of this article: National Oceanic and Atmospheric Administration (Donald C. Winner, Jimmie D. Johnson, R.W. Popham, Arthur Schwalb), NASA (Ken Senstad,) RCA Astro Electronics (Donald J. Norton, Frank Weaver) and ITT Aerospace/Optical Division (William G. Knorr).

OPENER TO OUR 50TH YEAR

The Society will open celebrations on reaching its 50th year with a new and very special type of event aimed at encouraging all our Members, both at home and abroad (and their wives!) to come and join us for Space '82. It will be a wonderful opportunity to see and talk about Space in all its facets and to meet many of the leading figures in the Space world today.

Make a note to join us and our speakers on 12-14 November 1982.

Our programme is developing all the time but here is a *basic* description of how things stand at present:

12 November (Friday)

Registration in the early evening is followed by an informal buffet supper with our President and Martin Fry, Space '82 organiser, who will welcome visitors and introduce some of our special guests.

13 November (Saturday)

This will be a very full day indeed.

Part of our programme includes: Dr. T.O. Paine (ex-NASA Administrator) and Raefe Shelton of British Aerospace posing the question. *The Energy Problem - Can Solar Power Satellites Provide the Answer?* Gene Roddenberry of Star Trek fame will speak on *Space: A Vision of the Future*, and Burt Edelson (COMSAT Vice-President) will consider *Space Communications - The Universe at Our Fingertips*. A session on *Into Deep Space* will discuss exploration of the deeper recesses of Space.

Breaks for coffee and lunch will give visitors the chance to mingle with our distinguished guests and see some of the displays (ESA have agreed to provide a collection of models).

An informal evening banquet will conclude the day. Some of our guest speakers will be Ted Mallet who will talk on *Europe in Space* and Rex Turner who will reflect on *The Society, soon 50 Years Old - A Look Ahead.*

14 November (Sunday)

Sessions will include speakers such as Dr. Garry Hunt (*Exploration of the Solar System*), Dr. Bill McLaughlin of JPL (*Evolution of Man and Machine*), and Capt. R. F. Freitag of NASA (*Space Industrialisation*).

This is only part of our basic programme. There will be many additions in the coming months to make this a not-to-be-missed event. Registration forms will be available from the Executive Secretary early next year, but get on our list now. Apply right away, enclosing a reply-paid envelope.

BOOK REVIEWS

An Amateur Radio Telescope
G.W. Swenson, Jr., Pachart Publishing House, 58 pp. 1980, $6.95

Radio Astronomy really originated as a science created by non-astronomers i.e. electrical engineers and physicists who applied their expertise to open a new range of wavelengths for the exploration of the universe. Since then amateurs interested in the subject have had to compete with two problems:

a) Radio-wavelength radiations are extremely faint, requiring for their detection large antennae and intricate electronic systems, with corresponding cost and sophistication which put them outside most amateurs' means.

b) The popular notion that a radio telescope is simply a large paraboloidal reflector, whose radio receiver is only a minor adjunct, has misled many into ill-conceived projects, which has had a dampening effect on other would-be enthusiasts.

Advances in electronic techniques have now made it possible for a dedicated amateur to build a radio telescope at reasonable cost, with excellent prospects for success. This book describes such a project, a working telescope which was actually built by the author's students.

It is concise, to the point, and not only explains the general principles of design but also indicates some of the objects worthy of attention.

The Illustrated Encyclopedia of the World's Rockets & Missiles
B. Gunston, Salamander Books, 264 pp. 1980 £9.95.

This book seeks to chart the history and development of a number of guided weapons. It is divided into 11 sections, depending on the missile's function and deployment. Each section is preceded by an essay which outlines the development of the weapon type.

Actual missile entries are arranged chronologically by nation within each section, illustrated by a variety of colour and black and white photographs. These include shots of manufacture, launch and target-kill, cutaway and profile drawings, as well as line diagrams.

This, however, is more than just a catalogue of weaponry. The author places the history of guided missiles into perspective and comes to some chilling conclusions.

The diversity of the systems featured ranges from man-portable anti-tank missiles to ICBMs — from primitive remote-piloted aircraft of the pre-war years to multi-warhead missiles of today.

A picture of a German wartime missile, the Rhinetochter, appears on p. 149. This was the one actually displayed at an exhibition at the Science Museum shortly after the end of WW2. The first of the two persons shown looking at the missile is none other than John Humphries, a former member of the Society's Council.

The Star of Bethlehem Mystery
D.W. Hughes, J.M. Dent & Sons, 218pp, 1979, £7.95.

The mystery of the so-called Star of Bethlehem mentioned in the book of Matthew and enshrined in so many hymns and stories since has long intrigued scientists and laymen alike.

What was it - a Nova, Supernova, Comet, simply a legend, or was it something beyond the scope of science? Was it seen solely by the three wise men (not "kings," as they later became!); are there contemporary records for such an unusual event, or was it something that never really existed at all?

Dr. Hughes examines all of these, and many others, one by one, in an exhaustive study, using secondary information sources wherever available - though these are scanty enough. He takes, in his stride, a whole host of other things. Who *were* the three wise men (were there only three?), what prompted them to make their journey, and where did they come from and, strangely enough, do their remains lie in Cologne Cathedral!

In examining the various explanations postulated from time to time the author pays scant regard to Halley's Comet, at one time thought to be the source of the "Star". Since Jesus was born around 7 BC and Halley's Comet appeared in 12 BC, the dates do not appear to match. A bright Nova or Supernova is also ruled out, for a variety of reasons.

Eventually, the author vouches for his solution - nothing more than the conjunction of the planets Jupiter and Saturn which took place in that year and which must have been most spectacular, for the two planets were so close together that they must have appeared as a single brilliant object.

The book is a detective story, based on very few clues, but examined with a thoroughness which would have done credit to Sherlock Holmes.

Optical and Infrared Telescopes for the 1990's (2 Vols.)
Edited by A. Hewitt, Kitt Peak National Observatory, 1194 pp. 1980.

This report was prepared from contributions by members of the NGT Scientific Advisory Committee set up to look into various aspects of problems associated with the construction of very large telescopes.

The idea of building a very large optical-infrared telescope, much larger than anything currently in existence, has been under discussion for some years. Giant strides have been made in Astronomy over the last 30 years but these have mostly come from telescopes built to explore electromagnetic spectra at wavelengths outside the optical band, and from the development of new kinds of detectors.

As far as photon-collecting powers are concerned, no major advances have taken place since the plan, more than 50 years ago, to build the Hale Telescope, though a new generation of 4-metre class telescopes and the Soviet 6-metre telescope, plus detector advances, have added greatly to our capability of studying the universe.

The preferred size-range for future telescopes is upward of 10-metres, with a target of 25-metres — but many technical problems remain unsolved and there is no general agreement concerning design.

More than 200 participants attended a conference to discuss these problems in January 1980. The resulting volumes, reproduced from the original text and the ensuing discussions, contain 76 papers falling under 5 main headings.

The first group of papers are concerned with on-going programmes to provide new telescopes. The next discusses the relationships between space and ground-based developments, with emphasis on the various types of space telescopes, particularly those to be used in connection with the Shuttle.

After a short section on instrumentation and detector advances, the next major section is concerned with indicating the work-load to be done with large telescopes in the 1990's, though the author introducing this key theme explained that trying to predict the problems which will attract stellar astronomers 10-20 years from now is rather like predicting the weather, and restricted himself to discussing supergiants, cepheid variables, halo stars, contracting stars, stars of very low luminosity, and stars in the Magellanic Clouds. By far the great majority of papers in this heading were concerned with advances in technology, an emphasis continued in the next section with a smooth flow into a general series of papers on mirror construction, support fabrication and the like.

A final section was concerned with specific concepts e.g. interferometery with large aperture telescope arrays, innovative telescope design and manufacture, and even a paper on updating some of the older instruments.

There is no doubt that these two volumes represent an enormous compilation and provide a fascinating study of current views on the development, construction and utilisation of a wide range of telescopic facilities over the next decade which might well lead to an information-explosion of our knowledge of both stars and galaxies. One can only wish well the development of some of the exciting projects portrayed. If these ideas are anything to go by, astronomy is poised on the brink of a new era which will stretch current information-processing techniques to the limit.

Double Stars
Wulff D. Heintz, D. Reidel Pub. Co., 174 pp. 1978. Cloth cover $29.00, Paper cover $14.00.

Double and multiple stars are the rule in stellar population, single stars the minority — as the abundance of binary systems in the space surrounding the Sun shows beyond doubt. Most binaries, particularly, have become an enormously active and complex field in recent years.

Binary and multiple stars are related to many others areas of astronomical research. This inter-relationship is well brought out in the book, from basic fundamentals to modern observations, dynamical methods, results and deductions.

The present volume is an almost completely rewritten version of the

original 1971 German edition. Notwithstanding these changes, the author has preserved its scope *viz* to provide a bridge between topics of modern research and the current technical literature — methods as well as results — without requiring more astronomical background than that available from an introductory textbook.

This book is well suited to advanced undergraduates or graduates in astrophysics and astronomy. It can also be used as a textbook for courses on binary and multiple stars.

Asteroids
Ed. T. Gehrels, University of Arizona Press, 1182 pp. 1979 $19.95.

The University of Arizona Press enjoys the enviable reputation of never publishing a book which is less than excellent. This one is no exception. It was compiled with help from 69 collaborating authors who, jointly, have produced a much-needed survey of the minor planets which generally orbit the region between Mars and Jupiter, though some come in closer than Mercury and it may be a moot point as to whether the remote planet Pluto, which intercepts the orbit of Neptune, is really a type of minor planet also!

The meeting which gave birth to this volume was held in 1979 and surveyed the whole range of asteroid observations and data. It begins with an historical introduction, continues with exploration, the interrelation between groups of asteroids, their configurations and compositions and ends with a discussion of their origin and tabulations of various data such as light curves, types, spectra, orbital elements and family memberships.

In the early days, the discovery of each new asteroid was exciting to the whole scientific community but, with their rapid growth in numbers and subsequent annoyance stemming from their too-frequent appearance on stellar photographic plates, they attracted the unenviable description of 'vermin of the sky'. By 1900, the astronomical community had all but lost interest in them.

Even up to the 1950's minor planet work was the concern of only a devoted few. It is easy to find new asteroids, but time and effort is needed to follow them up with obtaining precise positions, computing orbits and ephemerides — and doing this over and over again so that the objects are not subsequently lost. It was not until the 1970's that studies of minor planets received an enormous boost, largely as the result of the space programme which, by then, had reached the stage of planning missions beyond Mars.

Much of the work in keeping track of these bodies falls on the Minor Planet Center which has been engaged in transferring onto magnetic tapes observations going back as far as the 1890's. The work is made more difficult because new minor planets are constantly being discovered, and at an increasing rate. In 1979, for example, the minor planets officially numbered reached 2125; this will surely exceed 4000 by the end of the century.

The book abounds with a mass of interesting information. The first 'Earth-grazer', Apollo, for example, was discovered in 1932 and attracted much publicity then. It was subsequently lost but re-discovered again in 1973. In June 1978 the occulation of a star by Hebe gave the impression that the asteroid had its own satellite. The same thing was reported during a stellar occulation by another minor planet, this time Herculina. Whether both are true and whether there are also 'multiple' asteroids has yet to be determined with certainty.

Another interesting area is whether meteorites originated, in some measure, from asteroid fragmentation. The whole question of collision by asteroids with planetary bodies, certainly in the early days of the formation of the Solar System, is of great interest.

It has been postulated that the two moons of Mars, Phobos and Deimos, might be captured asteroids. If this is so, then photographs of both satellites, taken by Viking, could be our first pictures of asteroids themselves. These pictures show the two satellites to be extensively cratered. The same thing is postulated for the smaller satellites of Jupiter and Saturn, though the discovery of the active volcanoes on Io indicate that not all craters are necessarily due to impacts.

One extremely interesting area lies in the difference in the nature and origin of comets and asteroids. It is suggested that asteroids were formed in the inner part of the solar nebula, whereas comets would have been formed farther away from the Sun, though the exact place of their origin is not specified. Originally the comets must have formed a large spherical cloud surrounding the planetary system, though the depletion of their population — which is still continuing — must have been drastic. Even so, there are comets with relatively small elliptical or almost-circular orbits and it could be that some objects, currently classified as asteroids, might really represent the remains of a cometary nucleus.

These theories, and many others, are discussed in this book. It is a 'must' for any serious student of astronomy as it represents a basic compendium of knowledge regarding a group of small, but exceedingly numerous and intrinsically interesting, objects in the Solar System.

Genesis: The Origins of Man and the Universe
J. Gribbin, J. M. Dent & Sons, 360 pp. 1981 £7.95.

Departing from the usual Earth-centred and moving backwards-in-time approach, the author starts his book at the very beginning of time itself i.e. shortly after the 'big bang'. From there he moves through to the origin of our Galaxy, the Solar System, the Earth, life and eventually to modern man, with a final chapter on the theme of 'Where do we go from here?'

The book is aimed at the general reader. No previous background in science is necessary. The author, who is also a journalist, is well versed in writing popular — sometimes controversial — books, so it is no surprise to find this one to be eminently readable.

The subject matter is one of intense current interest, made more so by the many discoveries in physics and biology in recent years which have shed much new light on both the origins of man and the Universe in which we live.

Readers will find this book enjoyable and stimulating.

Hamlyn Encyclopedia of Space
I. Ridpath, Hamlyn, 160 pp. 1981 £4.95.

This is not an encyclopedia in the recognised sense but a series of contributions on a number of topics ranging from our place in Space, through the Space Age up to the exploration of the planets and then on to interstellar travel with the possibility of finding life elsewhere *en route*.

The volume is written for the layman or for those developing an interest in Space matters for the first time. It is beautifully illustrated in full colour throughout, with a style of writing both easy and informal, thus rating it an excellent birthday or other present.

It includes several references to Daedalus, complete with a picture of Alan Bond perched above what appears to be a black hole, with a Daedalus model to the fore and a stellar background to the rear.

The book concludes with a short but useful glossary.

A Handbook of Quasistellar and BL Lacertae Objects
E. R. Craine, Pachart Publishing, 283 pp. 1977 $19.00.

This compilation is drawn from some of the most useful and historically important observational papers on the brightest of the quasistellar objects, the number of which is growing rapidly and already exceeds 600 in the short period since their first discovery in 1960.

The purpose of the volume is to condense the presently-known observational data for the brightest of these objects, and BL Lacertae objects into a single source of reference. It thus condenses several hundreds of scattered references.

The basic data has been tabulated in a series of data sheets for each object containing such fundamental information as radio source names, positions, finding charts, radio spectra and, where possible, other types of data including red shifts, photometry, spectral data, optical variability, etc. In each case the data is accompanied by a reference number to the original published source.

There have, of course, been earlier compilations of this type of information, though in most cases they have listed only the most basic of data, without comment and, furthermore, most are now well out of date.

There have, of course, been earlier compilations of this type of information, though in most cases they have listed only the most basic of data, without comment and, furthermore, most are now well out of date.

The objects included in this volume are limited to those down to mag. 17. The data sheet format varies widely in content and shows, in a striking manner, how little data is available for so many of these objects. In many cases even the magnitude is available only as a rough

estimate and in some cases spectra are not published.

The position of each object is given in 1950 coordinates and is generally accurate to 5-10 arc seconds though, for some objects, the optical position is rather crude: in fact, some objects have several positions published, all varying from each other by a few seconds of arc!

Material for the data sheets came from over 400 sources but this was by no means an exhaustive sample of the literature. The object 3C 273, alone, for example, has been discussed in well over 200 papers up to the date of publication so the avalanche, no doubt, still continues.

Discovering Relativity for Yourself
S. Lilley, Cambridge University Press, 425 pp. 1981 £17.50 cloth (£7.95 paper)

This book seeks to explain Einstein's Theory of Relativity to readers who would otherwise be daunted by a standard mathematical approach. The author, who has taught this subject to adults without science backgrounds for many years now, has prepared a text which requires no prior knowledge of mathematics or physics.

The first part of the book requires little more than arithmetic and simple geometry to introduce some of the basic concepts of the theory. When, eventually, further progress demands the use of algebraic and other mathematical techniques, these are carefully explained.

As a result, readers are gradually led to an understanding of the Theory of Relativity — not just the Special Theory but also the General Theory which has, up to now, required very sophisticated mathematical techniques.

Here the reader will find the apparent paradoxes, such as the Space Traveller who returns, having aged less than the twin he left behind, and also considers such modern developments as black holes and gravitational waves.

This is Relativity for the layman — easy to read, but, nevertheless, requiring some diligence in application.

The Edge of Infinity
P. Davies, J. M. Dent & Sons Ltd., 94 pp. 1981 £7.95.

Regions of the Universe are thought to exist where gravity is so strong that it overcomes all physical laws and structures. New and far-reaching discoveries indicate that uncontrolled gravity can twist space and time into destruction at so-called 'singularities' i.e. weird non-places where spacetime is ripped open and matter may enter or leave the physical Universe.

Singularities lie at the centres of black holes and mark the creation and destruction of the Universe. There, gravitational forces can become infinite. On the edge of such infinity, bizarre effects occur — time is reversed, cause and effect break down and matter is totally annihilated. Is this to be the ultimate catastrophe of the Universe? The author is adept at such matters: his book, well illustrated with lined drawings, will take the reader on a journey he will not easily forget!

The Recent Progress of Astronomy
E. Loomis, Arno Press, 257 pp. 1980 £18.00.

This is a book from the past — for the 1980 edition is really a facsimile of the original edition of 1851 — which will fascinate anyone interested in the history of astronomy. It is a small volume designed to present a popular account of some of the most important astronomical discoveries which took place in the 1840-50 decade, i.e. immediately preceding original publication.

A large part of the book is taken up with an account of the discovery of the planet Neptune, recounting the work of Adams and Le Verrier, which led to the announcement of the actual discovery by Galle, though Challis at Cambridge, on re-checking his observations based on the work of Adams, saw that he had twice observed the planet earlier without realising it.

It seems strange now to read about the discussion which took place over naming the new planet. Le Verrier favoured calling it Neptune, but his friend, Arago, declared that he would never call it by any name other than 'Le Verrier'. A similar situation had arisen earlier over the discovery of the planet Uranus by William Herschel; he had given it the rather ungainly name of 'Georgium Sidus'. This name proved offensive to the French national pride so, at first, they called Herschel, though afterwards Uranus.

Other exciting events occurred, too, e.g. the appearance of the great Comet of 1843, the disintegration of Biela's Comet in 1846, the rapid discovery of more asteroids and the opening up of the Heavens to the great optical telescopes, including the initial resolution of some of the nebulae by the Earl of Rosse.

The remainder of the book is taken up with the description of the then rapidly emerging American Observatories, including a section on longitude determination by means of 'The Electric Telegraph'.

The book is eminently readable. What a pity it contains no illustrations.

The Crab Nebula
S. Mitton, Faber & Faber, 194 pp, 1979, £6.50.

Nine centuries ago there was a gigantic celestial explosion with the result that a "new" star appeared in the sky and remained visible for almost two years. At its brightest it must have had a brilliance equal to about 500 million stars like our Sun. It left behind it an astonishing record of its own spectacular end - the fascinating Crab Nebula and fast-spinning pulsar.

Within the wreckage of the Crab, physical forces still battle for supremacy. Conditions unimaginable on Earth are encountered e.g. magnetism a million times stronger than any field created in the laboratory, matter a million million-fold more dense than lead, and gravity of overwhelming strength.

The author tells the story of the Crab Nebula - now known to be between five and six thousand light-years away, starting with observations in the 11th century and ending with its continuing influence on modern astronomy. He describes the structure and properties of the Nebula itself, the physics of the pulsar, the manufacture of heavy elements in the supernova explosion and compares the Crab to other supernova remnants.

Supernovae and Supernovae Remnants
C. B. Cosmovici, D. Reidel Pub. Co., 387 pp. 1974 $37.00.

This book, which contains the Proceedings of an International Conference of Supernovae held in May 1973, is unique since it gives a complete picture of the problems concerning the discovery and the detailed study of Supernovae and their remnants.

The most important points emerging from the Conference and brought out in this book are:

(1) The exciting possibility of using supernovae for determining distances in the Universe and so to learn about the structure and evolution of the Universe;
(2) a provisional determination of the frequency with which supernovae appear in different kinds of galaxies;
(3) the beginning of an understanding of the spectra of supernovae, of the amount of matter ejected and the physical conditions in the supernova shell;
(4) the report of the first detection of strong radio emission from a supernova which appeared recently in another galaxy;
(5) the elucidation of the detailed structure of magnetic fields and cosmic ray particles in supernova remnants from the measurements made with new powerful radio telescopes;
(6) the discovery of X-rays from many supernova remnants and a first analysis of the structure of some with the satellite Copernicus;
(7) the beginning of an understanding of the physics of supernova explosion and the kinds of stars in which it occurs;
(8) the construction of very detailed models of the structure of supernova remnants and their radio emission;
(9) the construction of more detailed models for the formation of pulsars and the way in which pulsars accelerate cosmic rays and generate magnetic fields which energise the supernova remnants.

NEXT MONTH

The February issue of *Spaceflight* will carry a report on the 32nd IAF Congress in Rome, plus a feature on transforming Venus into an Earth-like planet.

CORRESPONDENCE

Who's Counting The Days?

Sir, Re the *Spaceflight* front cover of the August-September issue. If the ARS began on 4 April 1930 and the IAS began on 1 October 1932 their 50th anniversaries take place in 1980 and 1982 respectively (not 1981). If the two merged to become the AIAA in 1963 then *that* anniversary is not due until 2013. So whose 50th birthday is being celebrated in 1981, and why the congratulations?

C. ALLAN
Stoke-on-Trent

In response to an enquiry from the BIS Executive Secretary, the Executive Secretary and General Manager of the AIAA, Jim Harford, replied:

'Leave it to those alert historians of space flight in the BIS to spot ambiguities. Christopher Allan is correct. The ARS was founded in 1930 and IAS in 1932. The Board of Directors decided to split the difference and have the 50th Anniversary celebration in 1981. Later, however, eloquent people spoke in favour of extending the anniversary from the May 1981 Annual Meeting through the May 1982 Annual Meeting. So that's what we're doing.

'It's not completely logical but we had a smashing time in Long Beach at the May 1981 event and we look forward to an even more splendid celebration culminating the anniversary year in Baltimore in May of 1982.'

BIS film

Sir, I was interested by Mr. G. C. Carter's letter in the August/September issue of *Spaceflight* on p. 235 proposing that a film be made by the Society.

I make television documentaries and I am afraid that I can offer little optimism for this idea.

.One hour of top quality documentary television now costs about £200,000 to make! One roll of 400 ft (10 mins) of 16 mm film costs around £100. Then you hire a camera and crew, develop it, grade it, and edit it losing 90% of shot footage. On a ten-part documentary series I completed recently we shot 26 miles of film.

Video tape of the modern technology variety is handy for news and simple single location work. Even using Electronic New Gathering equipment, any complex piece of work will require editing, and a video editing suite looks like something out of *Star Wars* and costs about as much per hour!

In fact, due to the fact that video tends to come with vans, engineers, and other extraordinary pieces of equipment, documentaries are almost always shot on film which is mobile, uses less light and gives a better visual product in the end.

In the particular case of the Society, much of your film would be made up of library footage which almost forces you to use film because the costs of transferring this to video are gigantic.

But that's all negative. Mr. Carter's notion is a good one. What he has to do is work backwards. He should decide what the film is for, who is going to view it, and in what form — a reel of film, a videocassette or a TV programme. Since you know your audience you can return to the basic idea and tailor it to your requirements. It is this rather beastly down-to-Earth approach that defeats most amateur film producers. The romance of the idea is terribly exciting, the reality of turning it into strips of celluloid is so difficult and frustrating that it keeps our industry small.

When you know what you want and why you want it, then you go and find a sponsor to put up the money!

EBEN WILSON
London

The Editor is always interested in receiving items of correspondence, notes, comments, or reviews for possible publication. Items submitted must be kept brief, owing to the limitations of space in our magazine. The Editor reserves the right to shorten or otherwise adapt material to fit, for this reason.

Intercosmos satellites

Sir, In [1] Philip Clark gives the masses of the Sandal-launched Intercosmos flights. In the original Polish publication [2] the masses of those Intercosmos satellites launched by the SS-5/SKean vehicle are also quoted:

Intercosmos	Mass(kg)
1	315?
2	~320
3	340
4	~320
5	340?
5	5500?
7	375
8	340?
9	340?
10	340
11	350?
12	350?
13	350?
14	372
15	422
16	370?
17	

The mass of Molniya 1 is also quoted as 1750 kg. The Vertikal/Intercosmos launches are quoted as reaching 487, 463, 502 and 1512 km altitudes (for Vertikals 1 to 4, the first three Sandal-launched, the latter by Skena).

Dr. H. PAUW
Netherlands

REFERENCES

1. Philip S. Clark, 'The Sandal Programme,' *Spaceflight* **23**, 1, p.20 (1981).
2. Pavel Elsztein, *Polska v Kosmosie*, Wydawisictwa Komunikaiji i Laczenosci (1978).

No sweat

Sir, Thank you for dispatching my ordered sweatshirts so rapidly. I am very pleased with them, so much so that I would like to order another large size.

I enclose a cheque which includes £5 for the Development Fund.

L. HAMM
Hants

BALLOT PAPERS

A member has pointed out that the ballot paper sent to him was blank on page 2, though the Scrutineers, who have to examine every ballot paper returned, report no other instance of this.

It is likely that the matter may be no more than a machine "skip" but, to be on the safe side, the Council asks any other member who may hold a faulty ballot paper to send it to the Executive Secretary for replacement forthwith.

THE BRITISH INTERPLANETARY SOCIETY

LIMITED (by guarantee)

ARE YOU INTERESTED?

*SOLAR SAIL

Have you noticed the Solar Sail Race round the Moon mentioned on the inside front cover of *Spaceflight* for October and the Space Technology Committee meeting held in November? There was also an excellent article in last September's *Journal* on using sail ships as interstellar craft. If you can contribute technical material, please send details.

*ART COMPETITIONS

Details of two art competitions are appearing: the 'Space 82' logo in December's *Space Education*, and an interstellar probe emblem to appear in the coming months.

*ASTRONAUTICS HISTORY

Why not support the work of the new astronautics history committee (news of this will be appearing shortly) by submitting material for publication in the astronautics history issue of *JBIS*. Do you have any photographs, artefacts or other items of a semi-historical nature which you would like to lend (or donate) to the Society for exhibit?

*EXPLORATION OF THE GALAXY

Technical studies of exciting new concepts, in furtherance of Daedalus, continue to appear in the Interstellar Studies issues of *JBIS*. Four issues we planned for 1982, available at a subscription of £6.00 ($15.00 abroad), post free.

*SPACE 82

An exciting new venture for the Society with rendezvous on 12th - 14th November 1982. Leading Speakers will discuss how space is likely to affect the future of mankind in innumerable ways. Follow developments as this programme takes shape. Special residential terms will be available.

*OUR NEW LIBRARY

Our library collection is growing apace. Do you have any specialised space literature, books, artefacts, slides, films - or even hard cash! - which you would like to give to augment our collection? The total for books and reports is edging its way to the 6000 mark, creating a unique space collection.

*HALLEY'S COMET EXPEDITION

The Society is investigating a trip to South Africa in March/April 1986 to gain a good viewpoint for the return of Halley's comet. Departure will be from the UK. A second trip, especially for American members, is also being organised. Full details will appear in both *JBIS* and *Spaceflight* later.

*SPACE CHRONICLE

Have you sent for a copy of our newest type of *Journal* issue: *Space Chronicle*? It's full of solid astronautics information on exciting topics such as manned trips to Mars and Halley's Comet probes.

*SPACE EDUCATION

First appearing in 1981, *Space Education* will appear twice in 1982 on a separate subscription from *Spaceflight*, cost £3 ($8.00) post free. It is vital reading for both teacher and ordinary member alike.

SPACEFLIGHT

Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 27/29 South Lambeth Road, London SW8 1SZ Tel: 01-735 3160

Correspondence and manuscripts intended for publication should be addressed to the Editor, 27/29 South Lambeth Road, London SW8 1SZ.

Opinions in signed articles are those of contributors and do not necessarily reflect the views of the Editor or the Council of the British Interplanetary Society, unless such is expressly stated to be the case.

Study Course

Theme: **REMOTE SENSING**

A course of evening meetings on the above topic, including a visit, will take place during the 1981-82 session. Details are as follows:

9 December 1981	Visit to the Laboratory for Planetary Atmospheres, Department of Physics and Astronomy, University College, London, accompanied by Dr. G.E. Hunt, 6.30-8.00 p.m.
6 January 1982	Remote Sensing: Needs & Applications in Developing Countries by Dr. E.C. Barrett
17 February 1982	Remote Sensing by Landsat and Weather Satellites by Dr. R. Harris
10 March 1982	Evening of technical films on Remote Sensing

The venue will be the Society's Conference Room at 27/29 South Lambeth Road, London SW8 1SZ. Lectures will run from 7.00-9.00 p.m. Course fee £3.00.

Application forms for registration are available from the Executive Secretary. Please send s.a.e.

Discussion

Theme: **MANNED EXPLORATION OF THE PLANETS**

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **13 January 1982**, 7.00-9.00 p.m.

The Space Technology Committee has organised this meeting to discuss the near-term possibility of manned exploration of the Inner Solar System, as part of its plan to form a study group to give the matter more detailed consideration.

Invited speakers will give a few short talks, to be followed by discussion.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Lecture

Title: **STARS - THE SOURCE OF LIFE**
by C.A. Whyte

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ on **20 January 1982**, 7.00-9.00 p.m.

Please note this meeting was previously advertised as 18 January 1982.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Lecture

Title: **RECENT ADVANCES IN OUR KNOWLEDGE OF THE SUN**
by Dr. G.O. Gough

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **27 January 1982**, 7.00-9.00 p.m. Please note the re-arranged date for this lecture.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

OUR SPACE LIBRARY

The Library will be open to members from 5.30-7.00 p.m. on each of the following dates:

6 Jan. 1982	13 Jan. 1982
20 Jan. 1982	27 Jan. 1982
10 Feb. 1982	17 Feb. 1982

While every effort will be made to adhere to the published programme, the Society cannot be held responsible for any changes made necessary for reasons outside its control.

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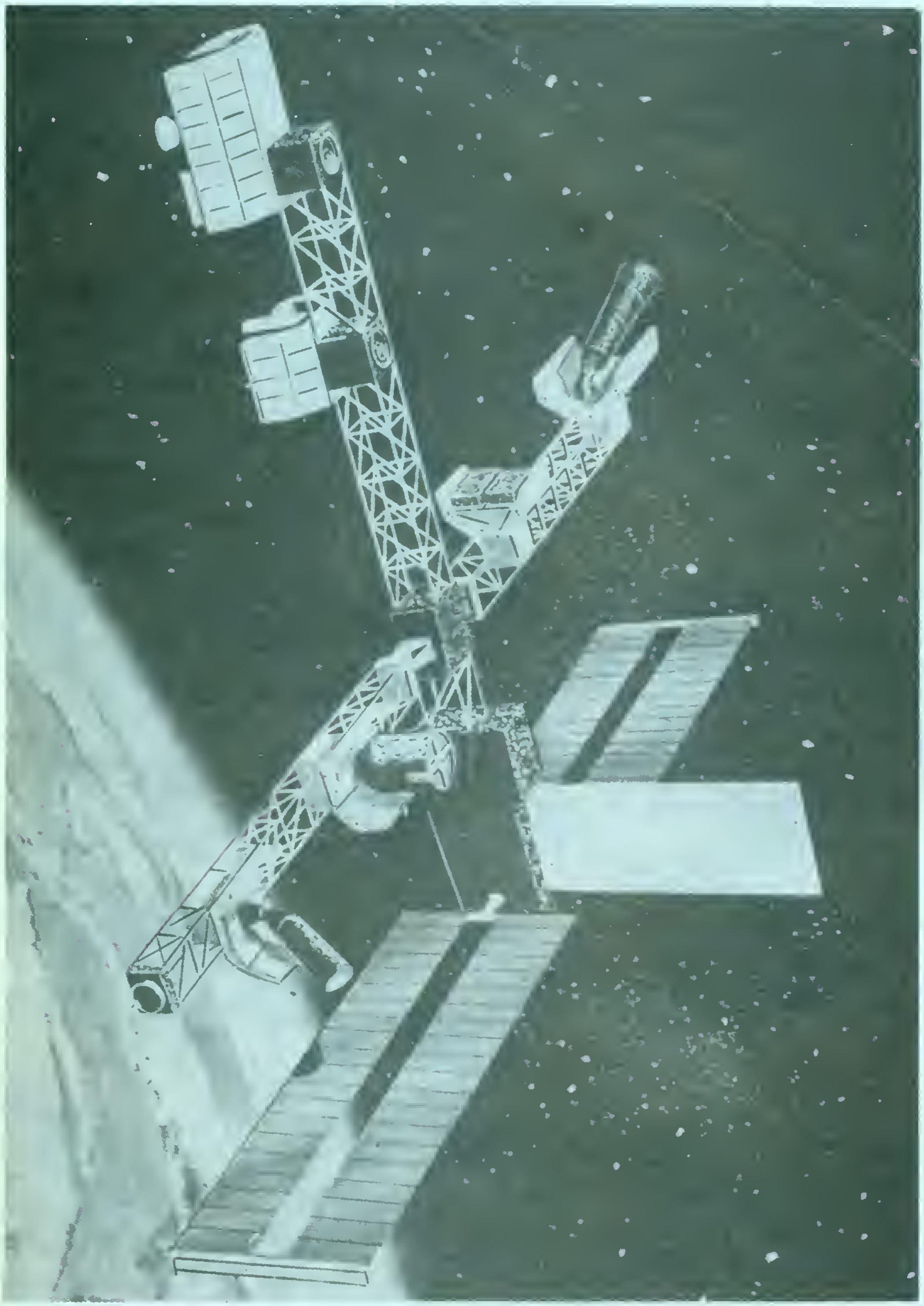
По подписке 1982 г.



Published by
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VOLUME 24 No. 2
FEBRUARY 1982

OPENER TO OUR 50TH YEAR

The Society will open celebrations on reaching its 50th year with a new and very special type of event aimed at encouraging all our Members, both at home and abroad (and their wives!) to come and join us for Space '82. It will be a wonderful opportunity to see and talk about Space in all its facets and to meet many of the leading figures in the Space world today.

Make a note and join us on 12–14 November 1982.

Our programme is developing all the time but here is a basic description of how things stand at present:

12 November (Friday)

Registration in the early evening is followed by an informal buffet supper with our President and Martin Fry, Space '82 organiser, who will welcome visitors and introduce some of our special guests.

13 November (Saturday)

This will be a very full day indeed.

Part of our programme includes: Dr. T.O. Paine (ex-NASA Administrator) and Raefe Shelton of British Aerospace posing the question: *The Energy Problem – Can Solar Power Satellites Provide the Answer?* Gene Roddenberry of Star Trek fame will speak on *Space: A Vision of the Future*, and Burt Edelson (COMSAT Vice-President) will consider *Space Communications – The Universe at Our Fingertips*. A session on *Into Deep Space* will discuss exploration of the deeper recesses of Space.

Breaks for coffee and lunch will give visitors the chance to mingle with our distinguished guests and see some of the displays (ESA have agreed to provide a collection of models).

An informal evening banquet will conclude the day. Some of our guest speakers will be Ted Mallet who will talk on *Europe in Space* and Rex Turner who will reflect on *The Society, soon 50 Years Old – A Look Ahead*.

14 November (Sunday)

Sessions will include speakers such as Dr. Garry Hunt (*Exploration of the Solar System*), Dr. Bill McLaughlin of JPL (*Evolution of Man and Machine*), and Capt. R. F. Freitag of NASA (*Space Industrialisation*).

This is only part of our basic programme. There will be many additions in the coming months to make this a not-to-be-missed event. Registration forms will be available from the Executive Secretary early next year, but get on our list now. Apply right away, enclosing a reply-paid envelope.

Editor
G. V. Groves

Assistant Editors
L. J. Carter
A. D. Farmer

Managing Editor
A. Wilson

CONTENTS

50 **Terraforming Venus**
Saul J. Adelman

54 **Shuttle To The Rescue!**
John A. Pfannerstill

56 **Welcome to Rome**

62 **Space Report**

67 **A Brief History Of The Voyager Project-Part 5**
Dr. J. K. Davies

71 **News From The Cape**
Gordon L. Harris

72 **India's SLV-3 Launch Vehicle**
Neville Kidger

74 **Salyut 6 Mission Report: Part 10**
Neville Kidger

79 **Space Communications**

80 **Satellite Digest-151**
R. D. Christy

82 **Astronomical Notebook**
J. S. Griffith

85 **Saturn's Spokes**
R. Beck and R. Koppmann

86 **Society News**

88 **Society Meetings**

91 **Correspondence**

93 **Book Reviews**

COVER

The Space Shuttle depends on expendable fuel for its electrical power, currently limiting its on-orbit life to about seven days. For longer missions, payloads could be transferred to the Science and Applications Platform (SASP) which would operate on solar power. British-built Spacelab pallets are prime candidates to support the experiments.

British Aerospace

SPACEFLIGHT

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VOLUME 24 No. 2 FEBRUARY 1982 *Published 15 Jan 1982*

MILESTONES

October 1981

28 Tenth anniversary of Britain's only orbital launch with the Black Arrow rocket. The 159 lb Prospero test-satellite was placed into orbit from Woomera, Australia. Designed for a one-year lifetime, it is still operating.

30 The Soviets take advantage of the 1981 Venus launch window by launching Venera 13 and (on 4 November) Venera 14. The craft will reach Venus in March and are expected to drop capsules to the planet's surface to make the first soil analysis.

November 1981

1 Norway becomes ESA's second Associate Member State (Austria is the first), for a period of five years during which time it may become a full Member State. Norway already takes part in the Marecs (Maritime Communications Satellite) and remote sensing programmes.

4 Press reports indicate that OTRAG, a privately-financed company aimed at developing cheap orbital launchers, is pulling out of its Libyan launch site. The company will concentrate on high-altitude, instead of orbital, rockets in the near future.

4 The first launch attempt of Shuttle *Columbia* in its second mission ends just 31 seconds short of launch. Oxygen pressure problems in the External Tank cause a longer-than-scheduled hold at T−9 minutes and then similarly with the Auxiliary Power Units (used for providing hydraulic power for the control surfaces) closer to lift-off. A 48 hr postponement is called, with the possibility of further delays.

9 ESA announces that the launch of Ariane LO4 from Kourou in Guiana has been postponed from 14 to 18 December because a strike at the Toulouse Space Centre in France has delayed the delivery of the Marecs-A satellite. The launcher itself has been at the firing site since 12 October.

11 An important telephone exchange in Lyon, France is destroyed by fire but services are restored within hours by using a small antenna and the experimental OTS communications satellite.

12 *Columbia* makes her second flight into space, with astronauts Joe Engle and Dick Truly aboard. The craft returns on 14 November, short of the planned 5 days, after one of the three fuel cells is shut down.

16 *Aviation Week* reports that NASA is considering the transfer of Shuttle mission control from Houston to the Kennedy Space Center in order to save money.

MEMBER SERVICES

Society Ties	*p. 70*	Magazine binders	*p. 92*
Sweatshirts/T-shirts	*p. 73*	Library Times	*back cover*
"Space Education	*p. 73*	Comet Excursion	*back cover*

TERRAFORMING VENUS

By Saul J. Adelman

We affect our local climate by changing the amount of dust and pollutants in the atmosphere, and the worldwide climate by raising the carbon dioxide level of the atmosphere. If such inadvertant activities can cause these effects, then deliberate acts might be able to substantially change the atmosphere of other major bodies of the Solar System. Within the past few years, several planetologists have begun to suggest how to terraform or to transform other members of the Solar System into Earth-like worlds. When there is sufficient energy to bring these changes about, our descendants may well undertake such activities.

Introduction

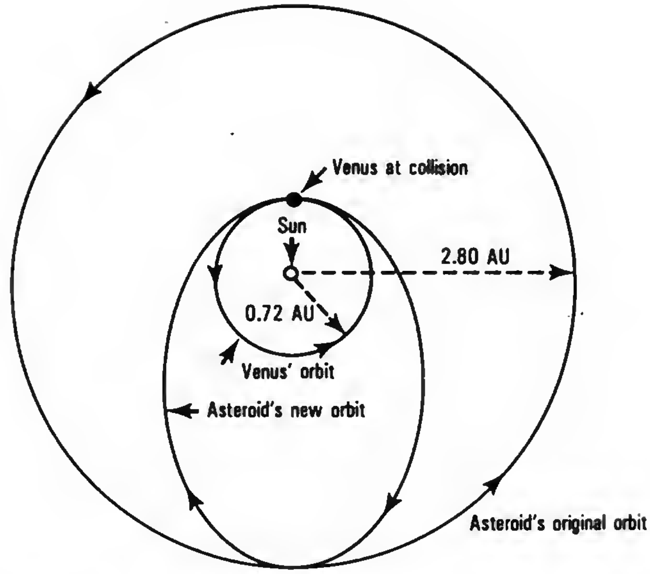
Terraforming projects will likely be undertaken only for relatively large objects such as Mars, Venus, and perhaps the Moon (where the changes will last for the indefinite future). The amount of energy required for these cases is enormous by the standards of our civilization and lies in the range expected to be achieved by civilizations which conduct interstellar flights. The most intrinsically difficult of these transformations is that of Venus. To see how it might come about, I carried out a series of calculations to obtain order-of-magnitude estimates [1]. The basic idea is to speed up the rotation of Venus by directing asteroids to crash into the planet [2]. Such collisions occurred during the early history of the Solar System.

Terraforming

To terraform Venus, we need to change the length of the solar day, reduce the atmospheric pressure, change the composition of the atmosphere, and lower the surface temperature. Since Venus lies 0.72 AU away from the Sun, it will have to absorb a smaller percentage of the solar energy that falls on it if the temperature is to be Earth-like. Since clouds are an efficient way of reflecting sunlight, we would expect our terraformed Venus to be cloudier than the Earth is now, but not necessarily as cloud covered as Venus is at present. To obtain the desired average daytime temperature of, say, 80°F, we need to have a relatively fast rotational period and sufficient (but not excessive) heat transfer to insure that the atmosphere near the surface does not become too hot during the day or too cold at night. It is difficult to predict the range of acceptable rotational periods and surface atmospheric pressures, but they certainly depend upon the final atmospheric composition and the wind structure. If humans are to move on the surface without space suits, the atmospheric pressure will have to be close to one Earth atmosphere and the rotational period close to about one day. The atmosphere will have to have sufficient oxygen for breathing and yet it must contain enough of an inert gas such as nitrogen or argon to make the composition biologically acceptable. There can be only a very low percentage of carbon dioxide.

A faster rotational period, or shorter solar day, is the paramount requirement. A possible approach might be to mount huge engines on the equator and fire them in the proper direction. But, at present, the atmosphere is too corrosive for such engines and their components, and this method is not particularly efficient especially in dense atmospheres.

If an asteroid hits the surface of Venus in the proper direction it can speed up the rate of rotation in accord with the conservation of angular momentum. Angular momentum is a measure of the rotational motion about some axis; when a spinning ice skater brings his outstretched hands towards his body, he spins faster. Likewise, an asteroid colliding with Venus can spin up the planet. If the asteroid is too small or moving too slowly, it will not be effective, but if it is too large or moving too rapidly, it might shatter the planet.



The Sun and the orbit of Venus are shown in relation to the asteroid's original and new orbits. The view is from North of the plane of the Solar System. Also shown is the point at which the asteroid collides with Venus. Arrows on the orbital paths indicate the directions of motion. The orbits of the second asteroid are similar to that of the first except that the new second orbit is rotated counterclockwise.

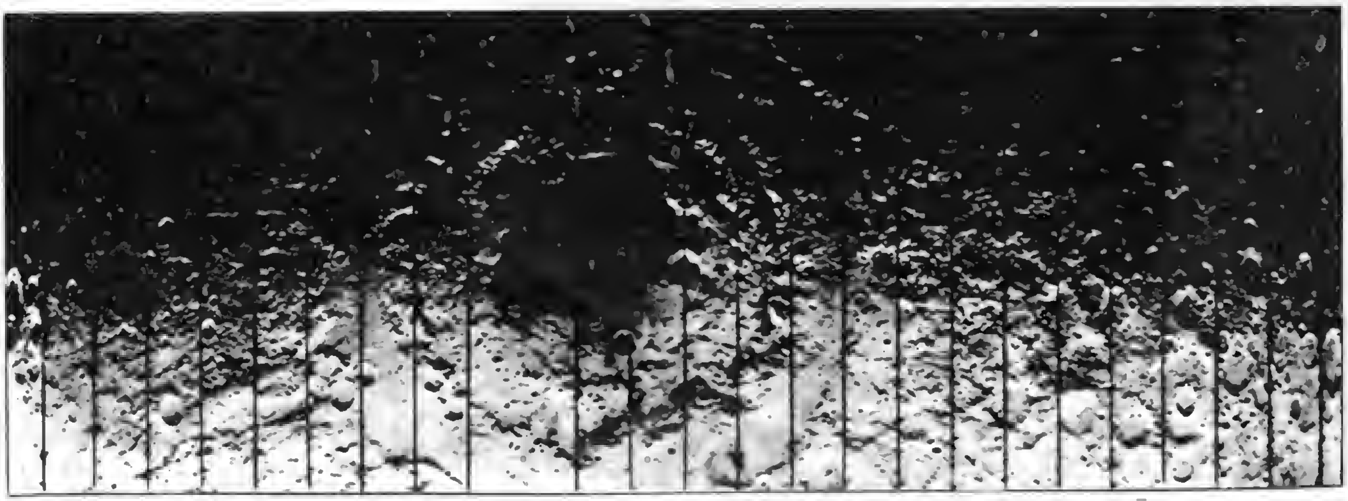
For projectiles, we want to use those asteroids which are as massive as possible for their size, i.e. the densest we can find. The densest commonly-found material in our Solar System is iron and there are several asteroids in the inner part of the main asteroid belt whose spectra are similar to those of stony-iron meteorites. We assume we can find two such objects 350 km in diameter composed almost entirely of iron. For comparison, the largest known asteroid is Ceres with a diameter of 955 km.

Most asteroids have nearly circular orbits which lie close to the main plane of the Solar System. Let us assume this is exactly true. Further, we need to assume radii for the orbits; Ceres is at 2.77 AU. We choose a radius of 2.80 AU for both asteroidal orbits.

The simplest orbit for the asteroid in which it will collide with Venus is one where its closest point to the Sun, or perihelion, is Venus' distance from the Sun, 0.72 AU, and its furthest point from the Sun, or aphelion, is 2.80 AU, its original

VENUS

In some respects, Venus is almost a twin of the Earth since it has 95% of our diameter and 82% of our mass. But it is completely cloud covered. The surface pressure is about 90 atmospheres while the surface temperature is near 850°F and is fairly uniform over the entire surface. The atmosphere is 97% carbon dioxide and 3% nitrogen, with traces of water vapour, oxygen, argon, neon, sulphur dioxide, and sulphuric acid. The solar day is 127 Earth days long, the period of revolution 225 days with respect to the stars, and the rotational period 243 days in a sense opposite to that in which it goes around the Sun.



The Orientale Basin on the Moon as viewed by Lunar Orbiter 4. The circular outer scarp, the Cordillera Mountains, is just over 600 miles in diameter. The Rock Mountains, within the outer ring, form another circular scarp 400 miles in diameter. This structure was produced by a small asteroid colliding with the Moon. In the centre some younger dark mare volcanic filling material can be seen – the collision of an asteroid with Venus would produce a similar structure.

NASA

distance from the Sun. The highest final rotation rate results when the asteroid moves so as to augment Venus' rotation. We have to change its direction in going around the Sun, i.e., put it into a retrograde orbit. To find the velocity of the asteroid with respect to the Sun at Venus' distance we use the principle of conservation of energy and end up with 44.3 km/s. The collision velocity is this value plus the orbital velocity of Venus with respect to the Sun (35.0 km/s) plus the velocity of escape from Venus (10.4 km/s). This latter term arises from the mutual gravitational attraction between the asteroid and Venus.

To produce the maximum speed-up, the asteroid should hit Venus as far from its axis of rotation as possible, that is, along its equator. Since the whole asteroid has to collide with the planet, this distance has to be somewhat less but the intersection of the asteroid's path and the planet has to be sufficiently large so that the asteroid will not penetrate the planet. The radius of Venus minus the radius of the asteroid is 5,881 km but to be certain the entire asteroid collides with Venus, let us assume a value of 5,800 km. Then the asteroid's path thickness in Venus is ten times its diameter. At the instant of collision the asteroid will be moving perpendicular to the Sun-Venus direction.

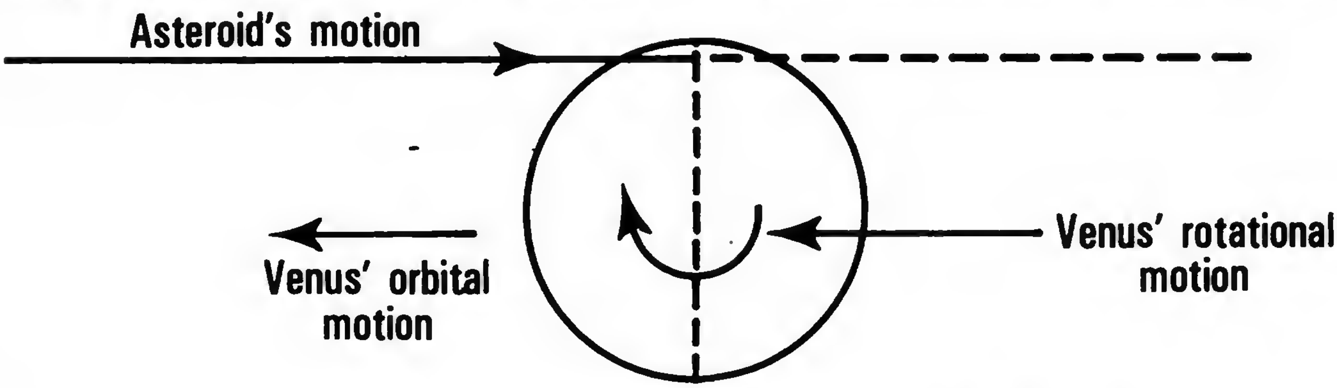
If we have two asteroids such as we have described and let them collide with Venus in the optimal manner, then the resultant solar day is 20.1 Earth days. This is a considerable improvement. We could repeat this experiment again and a solar day of 11.0 days would result. It would take 46 more identical asteroids to reduce the Venusian solar day to one Earth day but, unfortunately, there are not enough suitable asteroids to do this.

The alternative is to go back to huge engines on the planet's surface. This is a viable option if we can get rid of most of the atmosphere. In this case, it would take 12.6 years of operation in the same mode for the two engines such as we will describe to change the asteroids' orbits.

The second asteroid will be targeted to hit Venus on the equator diametrically opposite the first impact such that impacts occur at local midnight. The minimum time between collisions is half a solar day or half of 34.2 days, the length of the Venusian solar day after the first impact occurs.

These impacts, relative to the size of Venus, are similar to or more energetic than those which produced the largest lunar maria or the Caloris Basin on Mercury. If we use formulae which relate the size of the initial body and its energy to the final crater size, then we find that each crater will be 4,100 km in diameter. This is 12 times the asteroidal diameters or about 11% of the circumference of Venus.

Only about 2 parts in 10,000 of the asteroids' kinetic energy, that associated with their motion, goes into speeding-up Venus – the collisional mechanism is not efficient. In large part this is due to the constraints imposed by the dynamics of the Solar System. Most of the kinetic energy goes initially into making the crater and ultimately goes into heating the surface and the atmosphere. In fact, to give each atom of the atmosphere enough energy to escape from Venus requires only 2% of the kinetic energy of the asteroids but the molecules of the Venusian atmosphere will not receive equal amounts of energy



The motions of the asteroid and of Venus are shown at encounter. The asteroid's velocity is anti-parallel to that of Venus.

from the collisions. Some of them upon being heated will interact with the surface, while others will escape into space.

Each collision will generate a large shock wave in the Venusian atmosphere which will spread out from the impact path and move around the planet. Ultimately, it will focus diametrically opposite the impact point. Since each asteroid's speed is about 90 km/s relative to the surface, it will go through the atmosphere in only a few seconds. During that time, the atmospheric shock will not be able to move very far. The sound velocity near the surface is about 1.5 times greater than it is near the Earth's surface so the shock will move through the atmosphere faster than this and both heat and compress the atmosphere. Most of the atmosphere, especially in the region close to the impact path, will be heated to escape velocity. This shock will be augmented by the impact into the planet.

Besides the main atmospheric shock wave, each impact will produce massive shock waves in the interior. These will produce monumental Venusquakes, far larger than any recorded Earthquakes. Material thrown out from the crater region will produce secondary shocks in the atmosphere and the interior. The impacts will send up mountains of molten rock. The flight through the atmosphere and the impact itself will send shock waves into the asteroids to shatter and melt them. Magma from the cracked mantle might eventually fill the craters and if they are deep enough the planet will have to readjust its interior structure in order to restore its equilibrium. A series of terraces may develop as this restoration occurs. In these regions with molten rock, we can expect complex chemical reactions to occur between the remaining gases in the Venusian atmosphere and the hot surface.

The Earth is slowly releasing gases which are trapped in interior rocks - this happens, for example, when volcanoes erupt. The Venus collisions may well produce similar phenomena but the extent to which they would occur is difficult to determine. If we find that one of the volcanoes on Venus had erupted in geologically recent times, then we would expect the collisions to restore activity. Knowledge of such events is important, as well as a determination of the probable composition of the trapped gases, particularly as outgassing increases the mass of the atmosphere and would be counterproductive to terraforming activities (especially if the gases so produced had the wrong composition).

Acquiring the asteroids

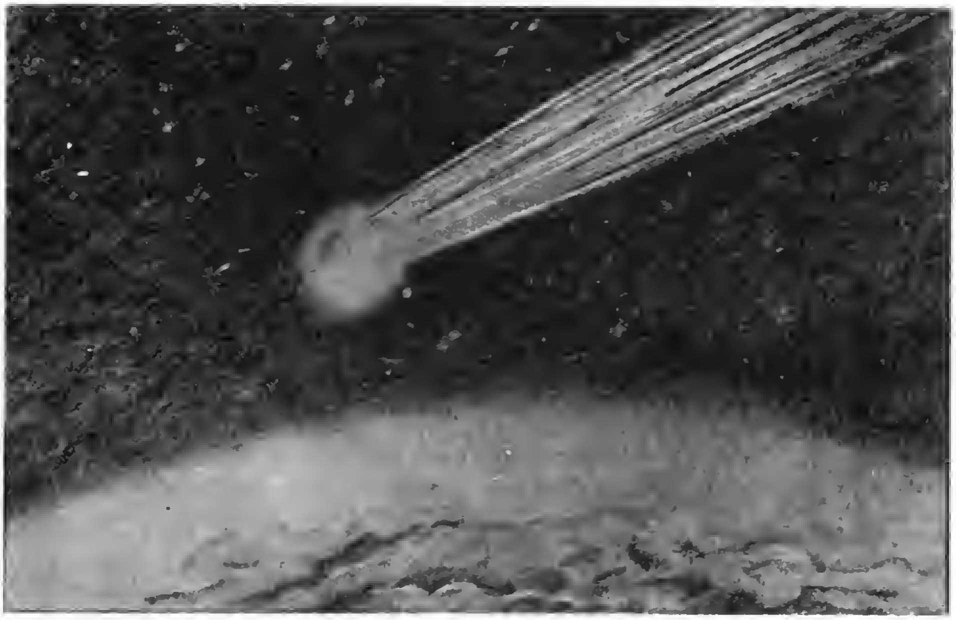
The next problem is that of changing the orbits of the asteroids. The choice of collisional geometry was made so as to be independent of the exact shape of the orbits. The asteroid is rotating about some fixed axis or axes in space so to change its orbit the thrust of any engine mounted on the surface must be directed in some specified direction for a considerable time. Thus, the asteroid's rotation must be stopped. We can achieve this by mounting an engine on its equator with the thrust opposite to the sense of rotation. Typical asteroidal rotation rates are of the order of 10 hours. If a full power burn is initiated with the engines we will adopt to power the asteroids, it would take only a 41 minute burn.

Once this stabilisation is completed, smaller engines can be used to correct any slight rotation. The main engine would probably be located in a pit and pointed so that its exhaust was directed away from the asteroid's center of mass. We have seen that the collision of the asteroid and Venus is not symmetrical so to help the material ejected in the impact collide with Venus, a slight rotation of the asteroid (in the sense that Venus orbits the Sun) might be induced with the thrusters when the asteroid is close to the planet.

To find the periods of the asteroids about the Sun, we use Kepler's Third Law. Their periods in their new collisional orbits are 2.33 years, compared with 4.69 years in their original orbits, and the time it takes each one to travel from the asteroid

The first asteroid approaching Venus. The view is from slightly above the orbital plane of the asteroid's new orbit.

Linda Kohl-Orton



A comet in the atmosphere of Venus. Part of the nucleus will vaporise during the descent – this is one way of bringing water to the planet.

Linda Kohl-Orton

belt to Venus is 1.17 years or 426 days. If the change of orbit takes place in a short time compared with the original orbital period, the calculations are simplified. We need to choose a time period of, say, 50 days. If we change this time we change the power of the engines required, but not the overall energy requirements.

The engines

The asteroid's velocity in its new orbit is 11.4 km/s at aphelion while it was 17.8 km/s in its original orbit. But since these velocities are in opposite directions, the change in velocity is 29.2 km/s. If the engines operate a constant thrust, we require a thrust which is about 10^{11} times as powerful as that developed by the Space Shuttle! We are dealing with an engine capable of powering a rather large starship to a substantial fraction of the speed of light. The most powerful engines which appear to be possible theoretically derive their energy from the annihilation of matter with antimatter and the result of such reactions is energy in the form of high energy photons or gamma rays. To make such an engine possible, an efficient mechanism needs to be found to produce large amounts of antimatter. Further, there are major engineering problems to be solved. Since $E = mc^2$ and we have a way in which to convert mass directly into energy, antimatter serves as a very compact form in which to store energy. However, one will never be able to produce it with 100% efficiency.

We need to maximise the thrust and thus distribute the energy generated to as many particles as possible. However, we do not want to use too much mass or we will consume a substantial fraction of the body. If too much mass is used up, then Venus will not be speeded up by the desired amount. If the annihilation reactions take place at 10^9 K, each asteroid engine uses 10^{12} kg/s as reaction mass. Over the 50 day burn, this is equivalent to 3.1% of the mass of each asteroid. It can be replaced by onloading material from other asteroids – it is equivalent to another spherical asteroid 55 km in radius. This is an enormous amount of material by our engineering standards. To make such a feat possible this material will have to be in gaseous form, which suggests that the iron minerals will have to be converted into a gas by high powered sources such as lasers. The thrust is one million (10^6) times that of engines proposed for manned interstellar flight.

At the front of the annihilation reactor will be a large chamber containing the iron vapour. As this gas is mixed with the antimatter in the reaction chamber the annihilation reactions will take place. This is a microscopic process. Gamma rays, pions, and neutrinos will be produced. The gas, which is in the form of a plasma, quickly reaches an equilibrium state and now moves into the vacuum of space through a nozzle at high velocity. Each second, 2×10^6 kg of antimatter is annihilated. This is equivalent to a sphere whose radius is 19.3 m if we are dealing with antiprotons. It may be possible to produce antimatter in the form of more complicated atomic nuclei such as anti-iron. In such a case, the density of the antimatter would be greater and the volume needed to confine a given mass less. The antimatter would most likely be stored in high vacuum at near absolute zero in the form of solid spheres suspended by electromagnetic fields.

Cometary nuclei could be made to collide with Venus after the asteroidal collisions to provide water, oxygen, and nitrogen for the atmosphere and future oceans. Their initial orbits are very narrow ellipses and it would take relatively little energy to change their paths – they are typically a few kilometres in diameter and composed mostly of ices, a good fraction of which is water.

Thus, terraforming Venus is possible if the enormous energy requirements can be met – the project is far beyond our present technology. We can ease the engine requirements if we extend the thrusting period. However, the total amount of power to be expended remains essentially constant. Another way of reducing the size of the engines is to use more, but less massive, asteroids. The scheme proposed here is a baseline study – ways may well exist to reduce the power levels further.

Once man achieves the ability to utilise very large amounts of energy, I am certain that the debate whether or not to terraform other planets will begin in earnest. How soon this will happen depends in large measure on how vigourously fundamental research is pursued as well as on the nature of the discoveries themselves. I do not think that it is too soon to broach the question, especially if the current level of research activity is increased.

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SHUTTLE TO THE RESCUE!

By John A. Pfannerstill

Introduction

A study has been performed at the Johnson Space Center to determine the feasibility of an in-flight repair by the Space Shuttle of the malfunctioning Solar Maximum Mission (SMM or simply "Solar Max") spacecraft. If the plan is approved, the repair mission could take place during one of the early flights.

Solar Max

Solar Max was launched into orbit on 14 February 1980 by a Delta launch vehicle from the Kennedy Space Center [1]. The satellite was designed to observe the Sun with seven precise instruments sensitive to wavelengths from far-infrared to gamma rays. The launch was timed in such a way that the bulk of its observations would be made in 1980, the most active year of the current 11-year solar cycle. The spacecraft had a design lifetime of one year, but it was hoped that it would continue to make useful observations for much longer.

The spacecraft functioned extremely well for the first eight months of its mission [2]. It observed the birth and development of several strong solar flares and provided solar physicists with a wealth of new and exciting information about processes going on inside the Sun.

But in November 1980, the $77 million observatory was crippled by the failure of an attitude control module which provides the fine-pointing capability for four of the instruments. The failure was eventually traced to faulty fuses in the module. The spacecraft itself and all of its scientific instruments were in fine shape, but the precision pointing capability so essential to the success of the mission was lost. It was at this point that the question of a possible Shuttle mission to repair Solar Max was raised.

Solar Max is the first of a new generation of standardised satellites specifically designed to be serviced by the Space Shuttle. Most of the components are modular in nature for easy pop-in/pop-out replacement, and most are designed in such a way that they can be replaced in flight with little difficulty. This allows relatively easy repair of minor malfunctions, such as the fuse failure, because such repairs can be done on-orbit without the added expense of bringing the satellite back to Earth, repairing it down here, and then re-launching it.

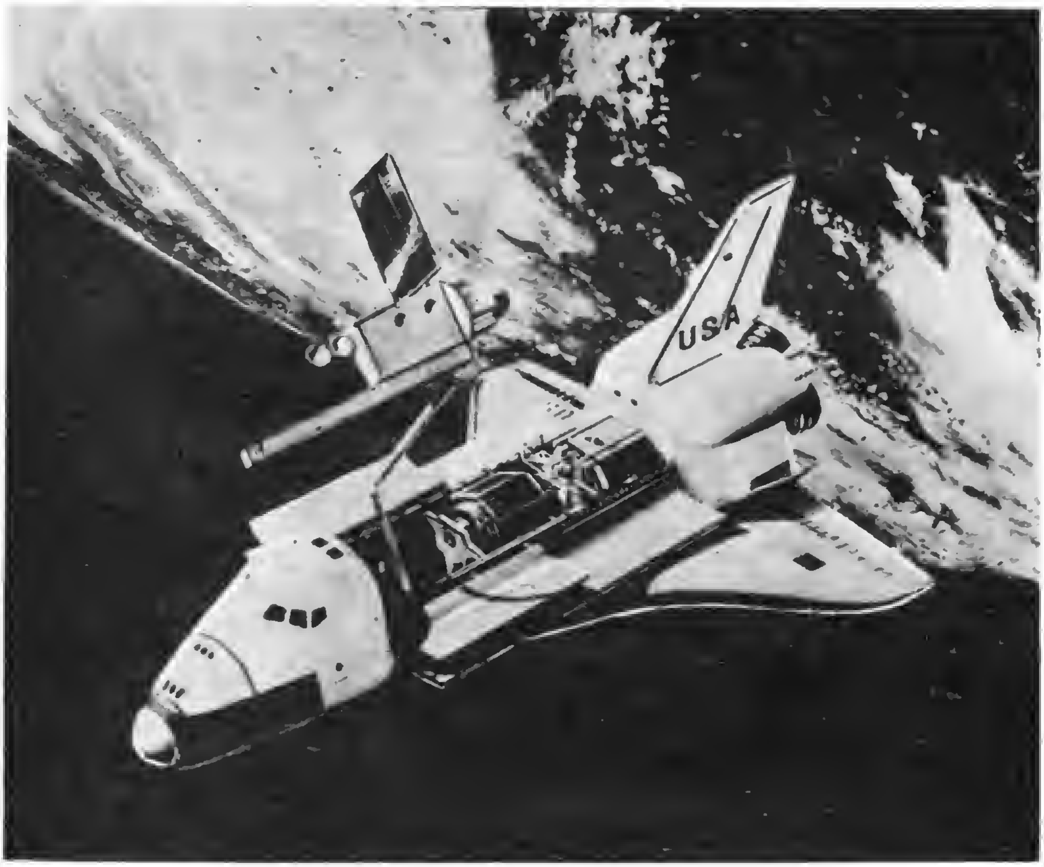
Well before Solar Max was launched, NASA had had plans to retrieve it from orbit on STS-15 in 1984. It was to be returned to Earth in the Orbiter's payload bay and was to be the first demonstration of the Shuttle's satellite retrieval capability. But with the attitude control module failure, the opportunity has arisen to provide an even earlier and somewhat more ambitious demonstration of the Shuttle's versatility as a satellite service station.

To the rescue

The Solar Max repair mission required no new hardware development and it is presently technically feasible to accomplish. For the Orbiter to achieve the nearly 550 km orbital altitude required to reach Solar Max, the payload bay would have to be devoid of anything not directly required for the repair mission.

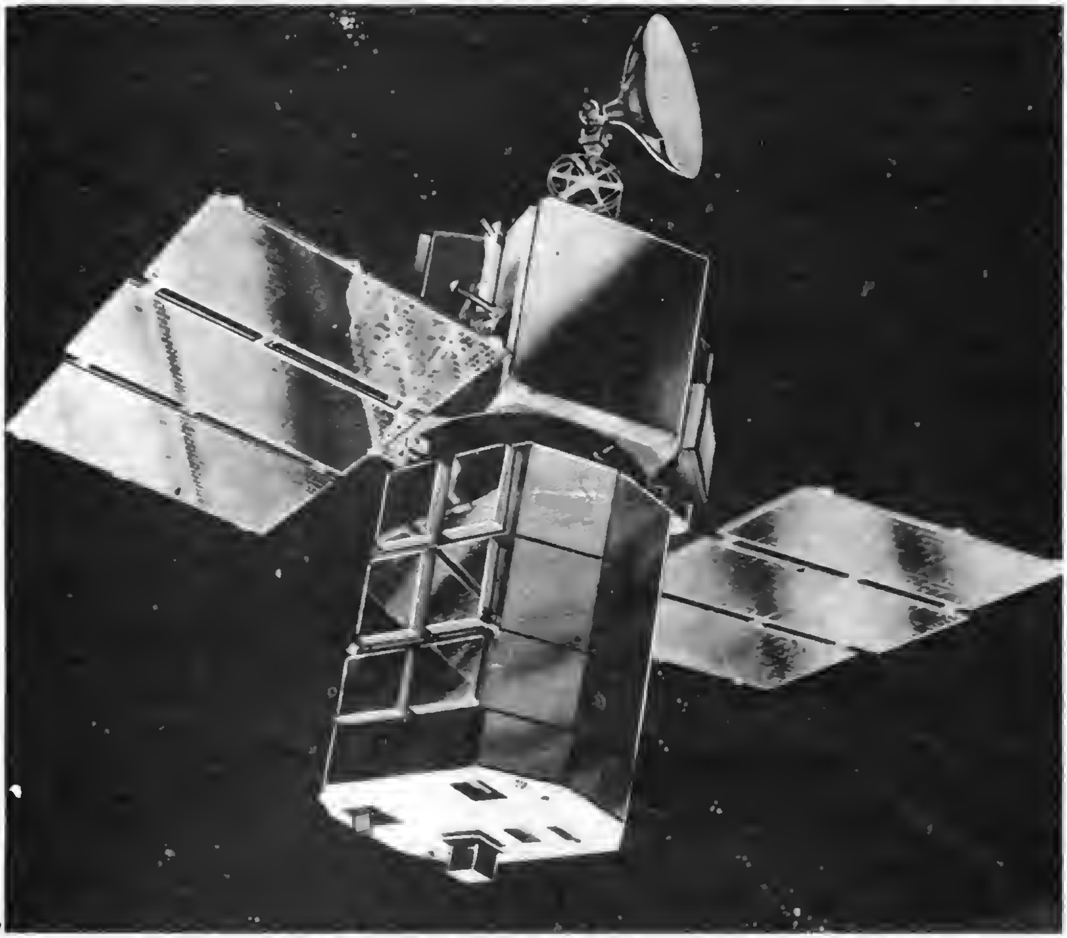
The repair mission would be launched from the Kennedy Space Center into an orbit inclined at 28.5 degrees.

The Orbiter would perform several burns of the Orbital Manoeuvering System (OMS) engines to achieve a rendezvous with the ailing spacecraft, which by that time is expected to be in a circular orbit of 540 to 515 km.



One of the functions of the Shuttle is to retrieve satellites for maintenance and repair. Some will be brought back to Earth and relaunched (such as the Space Telescope) while others will be repaired on the spot. The Remote Manipulator tested out by Engle and Truly during STS-2 will play a vital part in the operations.

NASA



The Solar Maximum Mission satellite is the first vehicle designed to allow Shuttle repair missions. It carries a Manipulator attachment point and its components are modularised to facilitate easy maintenance.

NASA

When the Orbiter gets close enough, the Remote Manipulator System (RMS) [3] would be deployed from the open payload bay and used to snare Solar Max on one of the satellite's special RMS-compatible grappling hooks. The RMS would then manoeuvre the captured spacecraft to a special collar in the payload bay called the Flight Support System (FSS). The Solar Max satellite would be fastened to the FSS during the actual repair work.

While the module replacement itself is a fairly simple operation, there are several possible methods being studied that could be used to accomplish it. Most of these centre around using the RMS from inside the Orbiter, an extravehicular activity (EVA) by a crewman outside the spacecraft, or the most popular method being looked at, which is a combination of both.

Under this procedure, one of the Shuttle crewmen would don an EVA pressure suit and backpack and go out into the open payload bay through the airlock in the Orbiter's middeck. Once outside, the EVA astronaut would climb onto a special "cherry picker" platform mounted in the payload bay. The cherry picker would have attachments to allow the RMS to pick the platform up with the EVA crewman on it and move it to the FSS collar on which Solar Max would be mounted.

Attached to a rack on the cherry picker within easy reach of the astronaut would be the tools required for the module replacement as well as the new attitude control module. To remove the old unit, the astronaut would be required to loosen only two bolts and then he would be able to pull it free. The replacement module would be installed in just the same way. The old module would then be attached to the rack on the cherry picker so that it could be returned to Earth for study. The astronaut would then go back inside the Orbiter after an EVA excursion lasting probably three to four hours.

After a checkout to ensure that the new module is functioning properly, the RMS would be used once again to detach Solar Max from the FSS and release it back into space. A second checkout would also be done with the satellite in free flight and the Orbiter station-keeping in its vicinity. Once it is apparent that Solar Max is again in operation, the Orbiter would move away from it and prepare for landing.

There are no plans to reboost the Solar Max satellite. Its natural orbital decay will cause it to fall back into the atmosphere in 1985 unless Orbiter-099 (*Challenger*) returns it to Earth in 1984 as originally planned.

Also, because of the unique nature of the Solar Max repair mission, it is possible that provisions may be made for one or two mission specialist astronauts to go along on the flight to perform the actual repair work. This would leave the astronauts free to concentrate on the busy schedule of Shuttle flight test objectives also planned for the mission. Astronauts Sally K. Ride and Dr. Joseph P. Kerwin have received extensive training in RMS operation and on-orbit satellite repair in simulators.

But if it is flown, the mission will prove the Shuttle's capabilities in a very practical money-saving way at a very early stage of Shuttle development. A successful Solar Max repair mission would bring a large boost in prestige to the Space Shuttle programme that NASA would be wise not to overlook.

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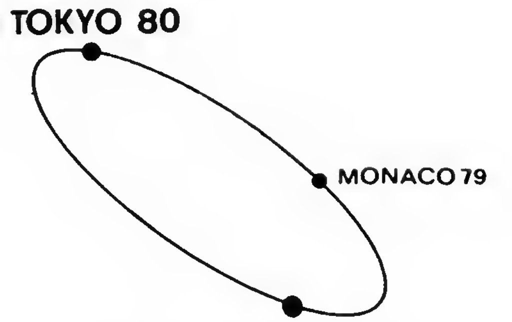
WELCOME TO ROME

THE 32ND IAF CONGRESS

Dr. L. R. Shepherd (Chairman of the International Liaison Committee) and L. J. Carter were the Society's official Delegates at the 32nd IAF Congress held in Rome from 6–12 September 1981. Here Len ruminates on the Congress, with comments inserted (some deleted!) by Les as appropriate.

IAF



ROMA 1981

All Roads Lead to Rome

They probably do, but some are more convenient than others. In the case of the 32nd IAF Congress, the route was via British Airways and, owing to a foul-up, involved an early morning start and a light snack in a plastic box collected from a Steward on boarding the plane, instead of the anticipated Roast Beef and Yorkshire Pudding.

Arrival at Rome showed all too clearly where the British Summer had gone to. Off came cardigans and woolly underwear in favour of exotic shirts and shorts.

Registration on Sunday was at the University of Rome, located by climbing several flights of steep and unmarked stairs, under an ancient arch, and a false journey into an imposing adjacent building which actually turned out to be a church, famous for its claim to possess the actual chains used to imprison St. Paul.

Next, and rightly, was the University – replete with the flower of the IAF, some looking slightly wilted in the heat by then. Registration was quick and, clutching a bag beautifully labelled and containing programme, maps, pen, paper and other goodies, one retired to the nearest restaurant to slake one's thirst and reconnoitre activities.

Opening Session

Nearly 1,000 people attended the Opening Meeting held at the Aula Magna of the Citta Universitaria to hear a message read from the Italian President, Giovanni Spadolini, and Addresses of Welcome by many other Dignitaries.

This was followed by two Invited Lectures, both on the theme of "Challenges of the Fourth Environment".

Those introduced were the Soviet cosmonauts Valeri Ryumin, the man who has spent the longest time in Space (two days on the first occasion, 175 on the second and 185 on the third), and Aleksei Elisayev with 150 days in Space to his credit, together with two American astronauts, Vance Brand, (Apollo-Soyuz) and Robert Crippen (Space Shuttle pilot).

The first talk, by Mr. Elisayev on "Development of the USSR Manned Space Flight Programme within the last 20 years," was of great interest but spoiled by the fact that the slides were projected so quickly that they could hardly be glimpsed before becoming invisible again. Some of the points made were:

(a) Salyut 4 had a 1.5 m reflecting telescope on board and, during the flight, this produced about 400 spectra of various regions of the Sun. The eruption of Mt. Etna was recorded. The surface of the Earth was photographed and information on the ionosphere and aurora collected.
(b) Vulcan Experimental Facility – Experiments in the welding and cutting of metals in space – Crystal furnaces used.
(c) Heat/Mass transfer in zero gravity conditions experiments carried out.
(d) Medical experiments – no after-effects upon the human organism were noticed.
(e) Experiments with plants were carried out, and also with seeds.
(f) The Russians had developed a large network of Earth and sea tracking stations for search and rescue.

Fortunately, visibility was restored during the talk by Bob Crippen, who discussed "The First US Space Shuttle Flight and its Implications for the Next 20 years." As always, Bob was ready to crack a joke, e.g. – referring to the Shuttle landing – he "liked to watch his movies for the ending always comes out so nice!" One of the nice things about the Shuttle was the amount of window space. This enabled astronauts to see cities, ships and runways: they were both surprised at what could be seen with the naked eye. For example, Edwards Air Force Base could be seen from 300 miles away: it was so clear that

Welcoming Address by Giovanni Spadolini, Italy's Prime Minister:

In extending my greetings to the participants in the XXXII Congress of the International Astronautical Federation I would like to stress the importance of the theme proposed: "Space: Mankind's Fourth Environment."

A fascinating theme, which recalls to mind a challenge of our times, the desire of Man to affirm life in an environment which a few years ago would have seemed unattainable.

Your Congress anticipates the Congress organised for 1982 by the United Nations, almost as if pointing out a synthesis, almost as if confirming that scientific progress, the discovery of new worlds and new spaces, in a word the conquests of Mankind, belong to the sphere of cooperation between peoples and drive back the disquieting hypotheses of destruction and conflict which sometimes reappear. Especially in an epoch in which we are perfecting new and deadly space weapons.

In the past, eminent men of science saw their discoveries put at the disposal of war, they saw the force of reason overcome by the logic of annihilation. A warning comes to us from that past: it is up to the men of the State to guarantee the conditions which safeguard peace and safety. A task in which the contribution of the scientists is essential and unrivalled. It is up to both of them to ensure a serene future to mankind.

In this spirit, which will certainly be echoed in your Congress, I express my best wishes for the success of your work.

The BIS delegates, Len Carter (centre) and Les Shepnerd (right), in discussion between sessions

Jim Hartford

they could have landed manually from that point, if necessary. The landing itself went so smoothly that they "couldn't even make it look hard." Perhaps the most fascinating piece of information was that the inflight check list for dealing with various contingencies weighed 65 lb!

To summarize, the first Shuttle flight, though solely a test flight, "operated far beyond our wildest expectations."

Vance Brand then referred to Shuttle plans for the next 20 years. These really needed the production of a long-term development programme – difficult to do in a country which is based on annual funding.

First he mentioned that he had been on the Soyuz/Apollo mission, and told a little story about an incident which took place during that mission. A mosquito had flown into the craft before launch, and before they lost sight of it it had survived weightlessness and the pure oxygen atmosphere without apparent ill effect. The insect's flying ability appeared totally unaffected by the zero gravity conditions.

He felt that the speed of advancement made of the past 20 years of space exploration would not be maintained for the next two decades, i.e. there would be a slowing-up period. However, demand for space transportation in the coming two decades would probably expand very rapidly. The high volume of satellites now in orbit must have an effect on future space activity. Greater economy was called for.

He spoke of antenna farms, which would be assembled by man and machines; of a continued improvement in the Shuttle's operational performance; of orbital transfer vehicles; and of manned platforms in low orbit to be used as staging posts.

The future will be very much affected by the value of satellite launchings – both in low orbit and in synchronous orbit.

Regarding the Shuttle, the need was to make it better (viz. even more economical and with improvements in performance), to progress towards the assembly of payload modules in low orbit. Later, in the 1990's, we needed to see the assembly of large structures in low orbit and the delivery of assemblies to high orbit. There was a clear need for a manned Space tug.

Technical Sessions

The week was divided into 12 morning and afternoon sessions, two of these being taken up by the opening and closing ceremonies and with only one afternoon session left "free." This meant that the Technical Sessions took up the remaining nine periods, though they were also run in conjunction with the Business (Plenary) sessions as well as meetings of committees, with the result that the choice of sessions which one could actually attend was drastically reduced.

Altogether, there were nearly 50 Technical Sessions run in parallel, each comprising an average of 8-9 papers, so the overall total presented was considerable.

Unfortunately, the experience of those who actually attended showed that the standard of papers varied enormously, with the number of really outstanding contributions showing a marked drop. This is, clearly, a matter which should exercise the attention of the IAF Programme Committee. Although an exceedingly large number of papers "bumps up"

Dr. George Mueller, Honorary Fellow of the Society. It was Dr. Mueller who, in August 1968, first made public at a BIS meeting NASA's thinking on the proposed Space Shuttle.

Len Carter accepts a medal, now displayed in the BIS library, to commemorate the 25th Anniversary of the Polish Astronautical Society from Dr. Olgierd Wolczek during the 32nd IAF (Rome) Congress.

Professor Carl Clemedson (BIS Fellow) and his wife.

W. H. "Bill" Stevens, former Director-General of the European Launcher Development Organisation (ELDO).

attendance, there is little doubt that "odd ball" papers detract considerably from the reputation of the Congress and absorb the time of participants, already ill-spared.

To avoid providing an inadequate survey of the Technical papers, therefore, an endeavour will be made in future either to cover individual papers of particular interest in depth or to concentrate on particular sessions only.

One such session was on the theme of "Space and the Mass Media." This proved most successful, even though contributions had been drawn from only a few countries. Details of technical papers likely to prove of interest will be covered in later issues of *JBIS* or *Spaceflight*, as opportunity arises.

Space and the Mass Media

This Session, appearing in the IAF Congress for the first time, contained several papers of particular interest.

First among these was one by B. Dubois about the 1981 Public Opinion Survey arranged by CNES to determine public knowledge and attitudes on space matters. The sample consisted of 200 questions put to 1,200 people, so an average of two hours was needed to deal with each individual!

The questions covered a number of main areas. Some were aimed at sampling public knowledge (or lack of it) e.g. 40% believed true the statement that "the Sun revolves around the Earth"! Life on Mars was accepted as true by 30%.

The second block of questions related to attitudes. For example, two-thirds of those interviewed agreed that space was of interest to the individual but the great majority also agreed with the premise that, instead of sending people into space, they should be more concerned with making a better life on Earth.

Public pessimism was apparent in the response to the premise that space will make Man better. This was not supported at all, though 70% of those interviewed expressed the wish to be space candidates!

By using the technique of clustering, it was found that people seemed to fall into six groups, as follows:

%	Category	Comments
15	Enthusiast	Interest not primarily based on detailed knowledge but basically emotional e.g. they read science fiction, culled horoscopes, etc. Mostly men of average ability who tend to over-estimate results. They possess very superficial knowledge.
18	Science-Eaters	These rely on popular science magazines and more realistically assess progress.
14	Enlightened	By far the best informed on space matters. A good knowledge, often a detailed knowledge of space. Fully aware of science and technological barriers and more realistic in appraisal.
11	Indifferent	A large female group. The main characteristic was the lack of knowledge of space. Their indifference extends to science in general. They understand very little of what is said about space.
17	Hostile	Also primarily female but different because they *defend* their attitude. Tend to be poorly educated. They grossly over-estimate costs and see no practical application. Part of them see space rockets as "a pollution of the universe." They fear that space will produce missiles hostile to their lives.
25	Forgotten	Primarily react against the costs – not of space itself per se. They attach little value to the acquisition of space knowledge and regard it as something that doesn't concern them.
100%		

Left to right: George James, Program Manager of the National Science Foundation and BIS Fellow; Ruth Howard, who acted as Secretary to the BIS delegation; and Les Shepherd.

It was made clear that these results applied solely to France. Quite different results might apply to other countries.

Another paper described how space communications directly assist the public media by providing continuous "real-time" transmissions. Reuters, for example, is connected to 65 ground stations served by Communications Satellites. We are now on the verge of a new development – satellites coupled to video transmission systems.

A further speaker pleaded for the provision of more technical material to journalists, to enable them to interpret developments to the general public. There was a major need to enlighten the public for it was surprising how much constant re-iteration of quite simple facts is needed. Specious references added little to public knowledge: "Knitty-gritty" was something of a premium. The difficulty in obtaining public support for space programmes, both in ESA and NASA, owed much to the lack of public awareness.

A paper read on behalf of Mr. Dowling described the preparation of special effects for film simulation of the space shuttle launch. This resulted in a film, five minutes long, which was distributed to 350 TV stations by Rockwell.

The programme sprang from noticing that there was no shortage of people queuing to see SF movies so an attempt was made to use similar ideas in the film. Apart from the models, artfully laid on appropriate backgrounds, sound effects were derived from actual space events. Simulating the rocket exhaust, using actual flame on miniature rockets, was actually done by adapting oxy-acetylene nozzles moulded to shape – though the heat posed additional problems in safeguarding the camera. This was overcome by using a jet of air to deflect the flame. Additional sound effects were provided by an electric motor fan from a coffee grinder, subjected to a noise speed-up and tone shift. Tiny bulbs were fitted to provide the flash which indicated the explosive bolts on separation.

A standing ovation was received by G. Pignolet for his paper which described how space, in the form of advertisements, is now featured increasingly. Advertisers use the "space desire" to sell their products, to the extent that their products may pose as actual spacecraft, e.g. cigarette packets arranged in the form of a space station!

Social Occasions

Monday evening included a Cocktail Reception put on by the President of the Societa Fianziaria Telefonica in the Capitoline Museum.

The route took us past the Coliseum, by the Forum, and eventually up a long flight of stairs overseeing an area where excavations were currently in progress. Once inside the Museum, a rare treat met the eyes, for this contained a fantastic collection of Roman architecture and sculpture, Sarcopheri, jars, statuettes, and memorial stones filled every room. We filed slowly through to an inner courtyard, itself graced by more marble remains. Then followed a candlelit ascent to a rooftop area which provided a beautiful view of Rome, but was itself dazzling with tables beautifully adorned with salads, savouries and wines, not to mention candelabra for additional effect.

There the delegates stayed, chatting among themselves in numerous ever-changing groups, until it grew quite late.

Ladies Programme

The Ladies appeared to have it good all the way. Spies reported that the Ladies claimed the best of everything – fashion shows, philatelic exhibition, shopping expeditions, guided visit to the Vatican, Museums, visits to villas, archaeological excavations and a Concert, to boot.

All the writer got out of the Grandeur that was Rome was a quick sneak round the Coliseum, almost at dead of night, and a supersonic lurch through the Forum which allowed about six seconds viewing time per ruin.

Congress Newspaper

Three issues of a Congress Newspaper appeared, printed in English, containing both Congress News and general information about Rome, including descriptions of some of the nearby monuments.

Business Sessions

Twenty six out of the IAF Membership of 60 organisations answered the roll-call and then proceeded to deal with the admission of new organisations. Only one new member-Society (SUNSAT Energy Council) was elected, but five Institutional (non-voting) members were added. One voting member i.e. the Iranian Astronautical Society, was deleted.

This was followed by a general discussion on voting powers. The present IAF Constitution deputes voting rights to one member-Society in each country. In the past, practically every decision ever made has been done by concensus so all have

been virtually unanimous, but the *principle* is raised from time to time, e.g. should this practice be continued, or should every Society have a vote? Additionally, should the voting be calculated in accordance with the number of members (one vote per man) or the financial support (one vote per share) given to the IAF? Why should Institution members be excluded? Indeed, should a simple vote for each country be shared, with each member-organisation holding a fraction!

Should there be "special cases", e.g. Taiwan and the Peoples' Republic of China counting as two bodies, each with voting rights?

There are reasons pro and con for each of these arguments, e.g. if each body had one vote, there is nothing to stop a country with a large number of small Societies being able to influence the IAF unduly by virtue of its enhanced voting power.

In the event, the voting position was left exactly as it was.

A Nominations Committee was appointed, with representatives from Sweden, Switzerland, Poland, Indonesia and China, to consider elections to the IAF Bureau. They reported later, re-electing the Bureau en *bloc*, though, in fairness, it ought to be added that they felt other Societies ought to be represented on the Bureau and were sorry that those approached were not prepared to accept nomination.

The IAF History Committee has recommended an Award to Mr. K. W. Gatland – a long standing Member of the Council – in recognition of his recent outstanding book *History of Space Technology* (Salamander Books)

An even more animated discussion took place on whether IAF Congresses should be held annually or every two years, with effect from 1984.

The proposal from the IAF Bureau was that, from that year, IAF Congresses alternate with COSPAR meetings, now held every two years, though with the proviso that:

(a) Symposia on specialised topics continue to be held.
(b) COSPAR would allocate time for IAF Papers at its meeting and, similarly, the IAF would make provision for COSPAR Papers in its own Congress.

A number of delegates were against this change and argued to that effect fiercely. However, the matter was resolved by vote on the basis of two specific proposals:

(a) *To maintain yearly Congresses until either there are no invitations or there is documented evidence of declining interest of IAF Congresses.*

The result was 11 in favour with 9 against, plus 4 abstentions. As there were only 11 in favour (although it was a simple majority) out of a total voting power of 25, the President declared the motion lost.

(b) The second motion read:

To invite the IAF Bureau to circulate a paper on the pros and cons of annual and bi-annual Congresses – the first gap to appear in 1984 with a final vote taken at the Paris Congress.

This brought 13 in favour, five against and four abstentions. The President declared this motion carried.

Further agility in the conduct of the sessions took place in the discussion of the registration fee payable for the next IAF Congress, planned for Paris in 1982. The proposal was that the registration fee be increased to $180 but many delegates felt that the rise over the past two years had been altogether too steep.

Others thought there should be a differential, with members of supporting Societies paying less, though this was rejected on administrative grounds. In the event, the registration fee was reduced to $165.

In fixing the arrangements for the next Congress, also, although the Programme Committee was virtually re-elected once more, it was pointed out that a number of papers had been presented at Rome which were not of a particularly high standard – thus pointing to the need for a more critical reviewing procedure.

The matter of IAF funding brought forth the statement, and the production of a paper, indicating that future demands on member Societies will be measured in terms of "units of support" – the magnitude of each "unit" to be fixed by the General Assembly on the recommendation of the Finance Committee, coupled with the suggestions that, initially, a "unit" should be in the sum of $150.

This was altogether too woolly. Very few delegates were able to follow exactly what was involved in all this, still less to determine what it meant in terms of actual financial commitment by each body.

A quick glance at the notes then circulated did little to provide assurance, so the delegates decided that they would best go home to think about it. In the interval, the Bureau would provide invoices, apparently in Mark I and Mark II versions, to enable each Society to know exactly what it had to pay and, no doubt, to ponder over the fact that the IAF derives substantial sums from each Congress so their earlier decision to hold Congresses every two years clearly involved financial considerations which may well bring the chickens home to roost in the shape of more (or bigger) "units of support." This led on to the slightly embarrassing fact that the budget for next year was not approved, for the simple reason that it had not been distributed!

As a way out, it was agreed to accept a budget, provided that it didn't exceed last year's total; this arrangement was perfectly satisfactory on all counts, the more so because it was ingenious, effective, and quick!

Congresses for the next two years were fixed i.e. (a) Paris, France, 27 September–2 October 1982; and (b) Budapest, Hungary, 9–15 October 1983.

After approving the "Staff Rules", the Business Sessions ran out of time, with the result that various Reports, *albeit* in summary form, were re-scheduled for presentation at the concluding session, thus spinning *that* out beyond its scheduled closing time.

The rest of the agenda found its last repose in limbo.

Space Activities in the Year 2000

The 33rd IAF Congress will be held in Paris (France) from 27 September–2 October 1982. The theme will be "Space Activities in the Year 2000."

Special symposia will include:

(a) Space Transportation Systems.
(b) Communications Satellites.
(c) Earth Observation from Space and Earth Environment.
(d) Science and Processes in the Space Environment.
(e) Space Energy and Power.
(f) Technical Sessions on Astrodynamics, Propulsion, Materials and Structures, etc.
(g) Industrial Contributions to Space Technology.

"LEX SPATIALIS"

The 24th Colloquium on the Law of Outer Space was held in Rome as part of the 32nd IAF Congress.

Subjects considered ranged from the legal status of space objects to the legal implications of economic activities in space, institutional arrangements, and space transportation systems, and as usual attracted lawyers from a wide range of nationalities.

The impact of the Space Shuttle was evident in the number of papers dealing with commercial activities in space. Professor

Böckstiegel (West Germany) stated that commercial operations were important and not forbidden if in conformity with the law, declaring that the State which asserted that an act is forbidden has the burden of proving it. G. C. Reijnen (Netherlands) was of the view that the Liability Convention of 1972 was wide enough to cover private space activities, while G. Gal (Hungary) urged that the Shuttle should be regarded as a spacecraft throughout its mission, although the legal systems of some European countries might seek to treat it as an aircraft.

In wondering whether the Shuttle can lawfully be used for commercial operations, Brigadier-General Menter (USA) said that some government aircraft are used for civil purposes, while recalling that in the case of non-governmental space vehicles the 1967 treaty requires authorisation and supervision of activities by a state (Article VI). Increasing manned and other ventures into space will lead to an increase in joint international projects with consequent joint launch liability under the existing space treaty. NASA agreements with users of US launch facilities now contain provisions for compulsory insurance and also cover infringements of patent law. He also considered that West Germany, which does not approve of the operations of the private organisation OTRAC should not be liable for its activities, but Libya, where its rockets are launched.

V. S. Vereschetin (USSR) called for further regulation in matters of space jurisdiction and safety as well as responsibility for damage and for military activities. He declared that the Soviet Union has always used space for peaceful purposes and asserted that some of the Shuttle's military uses are forbidden by the 1967 treaty, such as the destruction of other satellites. He commended the latest proposal by Mr. Gromyko for a treaty banning all weapons from space and not just nuclear weapons as provided by Article IV of the 1967 Space Treaty. He also warned that since the astronauts' activity in space is deemed to be on behalf of all mankind, military activities may prejudice their future status and possible return, despite the requirements of the various treaties that such astronauts should be promptly returned. This strict view was, however, challenged in a subsequent discussion in which the position of OTRAC was widely discussed, the Soviet view regretting the intervention of private as opposed to state organisations in space, and regarding the position of OTRAC as unsatisfactory. While Professor Carl Q. Christol (USA) agreed that West Germany should not be liable as she had not procured the launching, but had even discouraged it, Professor Böckstiegel conceded that active participation in lift-off is necessary to found liability for launching, but considered that she might still be liable under general international law for any mishaps since her nationals were involved. Mr. Jasentuliyana of the United Nations Organisation said that he considered the topic as an important one and regarded the International Institute of Space Law as a useful forum for discussion of the issue on a non-governmental basis. He also informed the Colloquium that the United Nations was considering the establishment of a new agency (International Satellite Monitoring Agency – ISMA) to monitor arms control inspection by satellite.

International organisation of Spaceflight was a topic dealt with in several papers. A call to make use of international organisations in space was made by Vladimir Kopal (Czechoslovakia), General Counsel of the IAF, and now a United Nations official. He regretted that only a few states had signed the 1979 Moon Treaty in contrast to the earlier four treaties, all of which had now been ratified by a large number of states. He announced that global interests were to be a priority at the U.N. Space meeting to be held in Vienna 1982, quoting the geostationary orbit as one of the most important legal items at the international level, and concluded that the existing orbit will accommodate the necessary traffic for the next two decades, provided that users co-ordinate their programmes.

M. Bourely (France), Legal Adviser of the European Space Agency, said that Europe was now the third space Power and international co-operation is essential to its future, ESA being designed for this function, while Eurospace and Eurosat fulfil a similar role among European commercial firms.

The need for various new bodies for space organisation was stressed by Professor Christol (USA), including planning and enabling bodies as well as executive ones, perhaps with different national voting systems. They must, however, command public acceptance. Dr. Okolie (USA) made a plea for the rights of developing countries in this field and claimed that the "common heritage" principle (used also in the Law of the Sea) is now part of international law. Nicholas Matte (Canada) the Director of the Institute of Air and Space Law at McGill University, reminded the Colloquium that the United States and the Soviet Union can learn to live together through the use of international organisations, also involving the Third World, and stated that the U.N. Committee on the Peaceful Uses of Outer Space had worked well in the past, but was now in need of up-rating.

Professor Pompeo Magno (Italy) informed the Colloquium in his opening address that the U.N. Legal Sub-Committee is considering further draft treaties on remote sensing of the Earth from space, direct broadcasting by satellite, the definition of outer space and the geostationary orbit, and the use of nuclear power sources in space.

Cyril Horsford

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SPACE REPORT

VOYAGER SURPRISE

Data from Voyager 2 seems to indicate temperatures in a region around Saturn ranging from 600 million to over 1000 million °F. Hot gas forms an enormous doughnut-shaped region encircling Saturn at an altitude ranging from 273,600 km above the cloud tops to as high as 724,000 km.

The temperatures are about 300 times hotter than the solar corona, and twice as hot as the Jupiter plasma cloud discovered by instruments on Voyager in 1979. The reason that the spacecraft survived passage through this region is that the density of the gas is very low, only about 30 particles in a cubic foot.

The Low Energy Charged Particle instrument is designed to measure fast (a few thousand miles per second) ions and electrons in the magnetospheres of the planets and in the interplanetary medium. The instrument can distinguish between several elements such as hydrogen, helium, oxygen, sulphur, sodium and others, measure the direction in which these high speed particles are moving and the temperature of this particle population when the plasma is very hot (tens of millions of degrees). The instrument is also capable of identifying the equivalent of the Van Allen belts and radiation zones in the magnetosphere of the planets.

The hot plasma torus seems to be centred around the orbits of Dione and Rhea, two of Saturn's icy moons, and to extend further away from the planet on the dayside than on the nightside. In this region of space Pioneer 11 and Voyager 1 experiments had shown the presence of a relatively "cold" plasma (temperatures of a few million degrees), which was a thousand times denser than the hot plasma identified by Voyager 2.

US/GERMAN SATELLITES

NASA and West Germany have agreed on a joint space venture: the cooperative project, Active Magnetospheric Particle Tracer Explorers, will use two spacecraft to study Sun-Earth interaction through active chemical release.

The mission objectives are to perform detailed studies of how solar wind ions enter the Earth's magnetosphere and the processes by which these particles are energised in the Earth's magnetospheric tail (the elongated portion of the Earth's magnetic envelope which streams away from the solar wind).

Tracer ions of lithium and barium will be released from the German Ion Release Module, and measured in the solar wind and within the magnetosphere by the American Charge Composition Explorer.

Ions will be released in three places around the Earth: in front of the magnetosphere at the sub-solar point; alongside the Earth at the magnetosheath (the boundary layer between the Earth's magnetic envelope and the solar wind); and inside the distant tail of the magnetosphere.

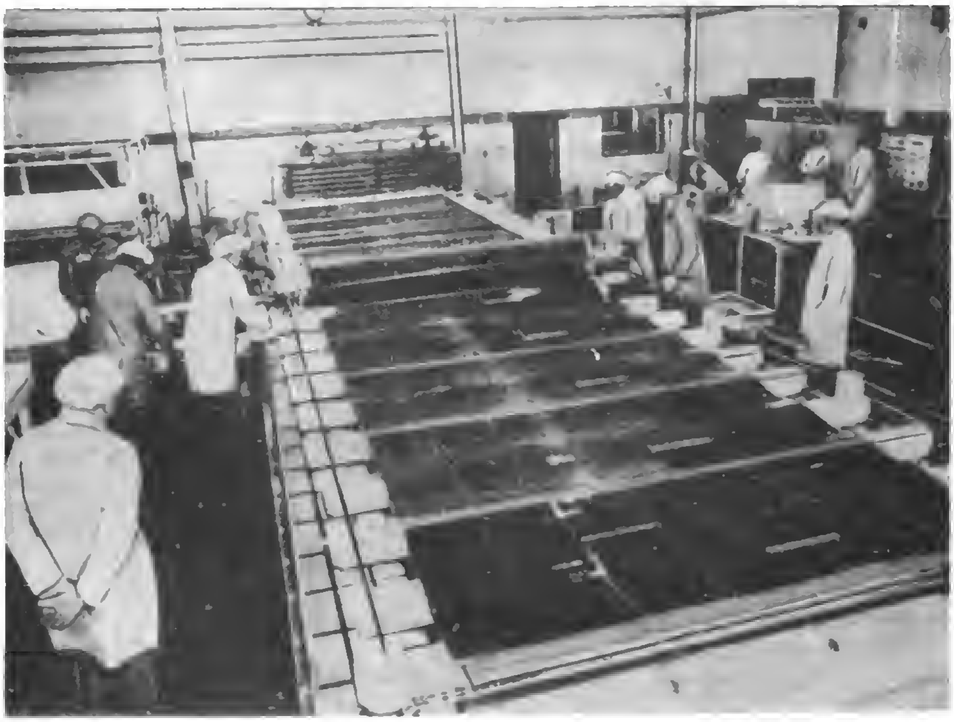
The use of different ions will enable the project to study both the composition and dynamics of the natural charged particle population within the magnetosphere.

To carry out this project, NASA and BMFT (the W. German Ministry of Research and Technology) plan to develop and launch two spacecraft. NASA will provide the Charge Composition Explorer for launch in 1984 on a Delta vehicle into a highly elliptical orbit with an apogee of eight Earth radii. The German Ion Release Module will travel aloft on the same vehicle but with an additional kick stage to place it in a highly elliptical orbit with an apogee of about 20 Earth radii.

SOLAR SAIL TEST

On 25 August 1981 a test version of the University of Utah and the World Space Foundation solar sail was successfully unfurled in its engineering deployment test at the Pasadena Convention Center, writes Joel Powell. The exercise was to test the deployment mechanism and its rolled-up stem booms, and unfurling of the kapton sail material.

As early as 1984, an Engineering Development Mission (EDM) is planned for the solar sail in Earth orbit, hopefully to be launched by the Shuttle. Initial apogee of the flight will



One of the two solar wings which will power the Space Telescope undergoes deployment testing on a water table at British Aerospace in Bristol. Electrical power – 400 watts – will be provided to the spacecraft's electrical subsystem for conditioning, storage and distribution. The Space Telescope is scheduled for launch aboard the Shuttle in 1985. The two arrays contain a total of approximately 48,000 solar cells and each wing measures about 8 ft wide and 18 ft long.

The World Space Foundation's solar sail during the first deployment tests. This 15 m-square prototype was built up from 38 cm-wide strips of aluminized Mylar instead of the expensive Kapton which will be used on the flight vehicle.

The BIS held a meeting on solar sailing last November; we hope to publish a report in the next issue.

Joel Powell

be 36,000 km, with the perigee raised to at least 1,200 km by a spacecraft manoeuvre on the first or second orbit to reduce atmospheric drag. The sail will then be deployed and oriented toward the Sun. By the pressure of sunlight alone (0.008 newtons or 1 g) perigee will be raised by 25 km/day with an acceleration of 2 m/sec per day. If operations continue for at least two years, escape velocity from the Earth will be achieved. The only payload would be monitoring instruments and the control system.

Later in the decade a more ambitious mission is planned, with possible scientific objectives of asteroid flyby or a Mercury mission. The engineering spacecraft will measure about 1,000–2,000 m² and weigh 150–200 kg while the follow-on vehicle may be twice that size.

DOUBTS ON SPS

Without further research a solar power satellite (SPS) programme would be a "high-risk" venture, says the US Office of Technology Assessment (OTA), which provides advice on science policy issues to the Congress, writes James Sweeney. The National Research Council (NCR), a branch of the National Academy of Sciences, which examines questions of science and technology for the US government, has recommended against funding SPS in the next decade.

OTA says "too little is currently known about the technical, economic and environmental aspects of SPS to make a sound decision whether to proceed with its development and deployment." Feasibility ultimately depends on social, political and institutional viability, OTA warns. Both agencies say there are no insurmountable technical problems, but cost estimates are extremely uncertain. Economics will play a major part in the future of SPS. NRC found that "the system compared poorly on technical and economic grounds with other prospective energy sources." The OTA report notes that, even if work began immediately, an SPS would probably not be available before 2005–15, which means it could not reduce American dependence on imported oil this century.

OTA also says public opinion on SPS is still not certain, and key issues would include: environmental and occupational health risks; land use, military implications and costs. OTA feels that the siting of land-based receivers could be an obstacle. The current controversy over the resources needed for the land-based MX missile system would seem to verify this prediction.

Space technology problems would also have to be overcome, according to NRC. Construction alone would require vehicles with 13 times the cargo capacity of the present Shuttle to take off more than once a day for 30 years, each lifting 400 tons of materials into low Earth orbit; 1,500 workers in space at any one time; and 1.9 million tons of steel for each of the 60 "rectennas" needed to convert the microwave energy into electricity on the ground. NRC looked at the possibility of using materials from the Moon or asteroids for construction, and found that "not only are important minerals lacking in those sources, but the technology for using them is far beyond foreseeable capabilities."

The space technology which would have to be developed for SPS would have military applications and enhance military space capability. OTA says the likelihood of the satellite portion of SPS being attacked is "only slighter greater than for major terrestrial energy systems." However, critics of SPS have contended that the vulnerability of the satellite would be an encouragement to increase the development of offensive and defensive weapons for space use.

Instead of a unilateral American project, OTA says a multinational project could have important economic and political advantages. These include: cooperation in establishing legal and regulatory norms; shared risk; improved prospects for global marketing; and forestalling fears of economic domination and military use. OTA mentions Western Europe and Japan as likely partners. The Soviet Union may have an independent capacity to build SPS, but little is known about its long-range space or energy plans. Real or perceived competition with the Soviet Union "could spur a US commitment to SPS."

SPS would "significantly increase US space capabilities," OTA says, "and in conjunction with other major space programmes, could lay the groundwork for the industrialisation, mining and perhaps the settlement of space."

EUROPE'S SPACE FUTURE

A resolution adopted by the European Parliament on 11 September 1981 called for a greater European involvement in space. It specifically requested early decisions to be made on the Ariane IV programme (the Intelsat VI communication satellites will need such a launcher in the mid-1980s), acquiring the technology for rendezvous and docking, and building large launchers and communications platforms before 1990.

Engineers Sally Little (left) and Don Ford of the Marshall Space Flight Center are conducting a solar array Sun shadow analysis on a model of the Gravity Probe-B satellite now under study and designed to verify portions of Einstein's general theory of relativity. The analysis was being done to establish data on the path that shadows take as they move across the solar arrays used to provide electrical power to the spacecraft. This data will then be used to determine the optimum configuration of the arrays to insure they capture enough Sunlight to maintain a continuous level of power throughout the year-long experiment. The first Gravity Probe was launched in June 1976 on a Scout vehicle.

NASA

EXTERNAL TANK SHIPPED

The External Tank for Shuttle mission STS-3 left the Michoud Assembly Facility at New Orleans on 29 September for the trip by barge to Kennedy.

ET-3 is a light brown colour (the first two were painted white) - the natural colour of the spray-on foam insulation. By leaving off the white paint a saving of 600 lb is made. Since the Tank is carried almost to orbit, this saving translates into almost 600 lb of extra payload capability. It also saves several thousand dollars in manufacturing costs.

Elimination of the paint will not adversely affect the tank's fire retardant or water repellant properties.

DELTA LAUNCH ERROR

When two Dynamic Explorer satellites were placed in orbit from Vandenberg Air Force Base on 3 August 1981 the craft failed to achieve their pre-planned orbits because of the failure by an engineer to make sure the fuel tanks of the Delta launch vehicle were filled with fuel, writes Gerald Borrowman.

Despite the error, the two satellites achieved orbit and the function of the experiments was not affected.

According to Ken Senstad, a NASA spokesman, "It was simple human error. It's the first time in memory that something like this ever happened as far as I know.

"We set up an investigation and after confirming this, revised our procedures so that it won't happen again."

According to project scientist Robert A. Hoffman, however, the lower-than-expected altitudes could eliminate NASA's option of continuing the experiments for a significant period beyond the initial 13-month programme.

Hoffman said NASA had hoped to keep the lower of the two satellites circling the Earth for 2-2½ years but because of the fueling mix-up, that satellite is now expected to remain in orbit for only 14½-23 months.

The Dynamics Explorers are designed to study the interaction of the ionosphere and magnetosphere, two regions above the Earth's lower atmosphere.

According to Senstad, the second stage of the Delta rocket was designed to carry 20,664 lb of liquid fuel. "But we have determined the rocket was 260 lb short at launch," Senstad said. He explained that the engineer who was monitoring the fuel operation "saw visual evidence of overflowing" through a special porthole but failed to double-check a second set of gauges before cutting off the fuel flow.

"I understand it was a little more complicated than that," said Hoffman, "I've been told they were using a new type of (visual) monitoring system and the engineer didn't realise that."

In either event, Hoffman said the first Dynamics Explorer had been expected to reach an elliptical orbit with a high point of 15,456 miles, compared to the 14,000 miles it actually achieved. The second reached 629 instead of 807 miles.

SMM OBSERVES FLARES

One of the instruments on the Solar Maximum Mission (launched 14 February 1980) satellite has detected several important new kinds of emissions from solar flares. The gamma-ray and neutron spectrometer showed that during a major flare on 21 June 1980, the first clear observations of neutrons reaching the Earth from a solar flare were made.

Neutrons are neutral sub-atomic particles created in nuclear reactions with flares. Free neutrons decay spontaneously into protons and electrons in about 15 minutes, so only the very high-speed neutrons can reach the Earth.

In the 21 June flare an intense burst of gamma-rays lasting about one minute was followed by a 20 minute stream of neutrons. This particular flare was probably the most intense to occur yet during this solar cycle.

In another flare on 27 April 1981, the instrument observed gamma-rays with energies characteristic of several varieties of nuclear reactions theorised but never before seen on the Sun. These reactions are caused when protons moving at nearly the speed of light collide with other atoms in the solar atmosphere (including nitrogen, silicon, magnesium, iron, lithium and beryllium atoms). This provides valuable clues concerning the abundances of different atoms in solar flares and the mechanism in which protons are accelerated to high speeds. A Japanese solar research satellite also observed this same flare and confirmed many features of the observations from NASA's satellite.

SPACE STATION WORK

A $355,000 contract to continue studies for a Space Operations Center has been awarded to Boeing Aerospace by the Johnson Space Center. Under the five-month contract extension, Boeing will continue conceptual design and mission analysis work on the space station. The Space Operations Center would serve as a permanent facility in low Earth orbit where satellites and other space vehicles could be assembled, serviced, launched and recovered.

The company's Large Space Systems group will expand its studies of potential research, science and applications missions and examine the implications of those missions. For example, Boeing will find out what impact a continuous manned presence will have on those missions. Economic studies of potential missions also will be considered.

The group will examine test, check-out and time requirements on board the Center for missions such as satellite servicing, construction and flight support. Considerations will be given to such aspects as crew time, communications, environmental control, data management and flight control. A timed development plan will be updated for building the space station and establishing alternative buildup sequences.

The Center could be used to establish manufacturing methods in space. This could be accomplished by testing particular manufacturing process components at the station to see if they are feasible for a separate free-flying spacecraft.

Changes to the basic design may be recommended to accommodate research missions and experiments on board. At present, the Boeing group has designed a general exterior and interior for the station which will allow basic missions to be accomplished, such as satellite servicing and construction. The Center could be operated by a crew of four to eight people who would live at the station for 90 days at a time. The Space Shuttle's external tank will also be examined for its potential use as a propellant storage tank or as a hangar for storing spacecraft.

Considerations will be given to the commerical, industrial, military and NASA scientific communities and a user charge plan will be developed similar to the current charge plan initiated by NASA for its Space Shuttle customers.

Examination of the effect of the Shuttle's remote control system plumes on the solar arrays, the effect of the Shuttle load on the thrusters and the effect of the docked craft on the centre of gravity will be made.

The proposed Orbital Transfer Vehicle would be used to place large payloads in an orbit beyond that of the Center. The Shuttle-Derived Cargo Vehicle could be used to complement the Shuttle by launching large payloads into high orbits or placing them at the space station.

A final requirement of the study is to examine the impact on the Space Operations Center design if it is placed in a geosynchronous orbit. Boeing will study additional design requirements for this geosynchronous orbit, such as radiation shielding and enhanced power supply systems.

SOVIET SUPER BOOSTER

The report *Soviet Military Power*, published by the US Department of Defense, claims that the large booster under development by the Soviets - possibly for launching a permanently manned space station in 1985 - will have a capability some "six-to-seven times" that of the Shuttle.

The USSR already orbits some 660,000 lb of payload a year - ten times the American figure.

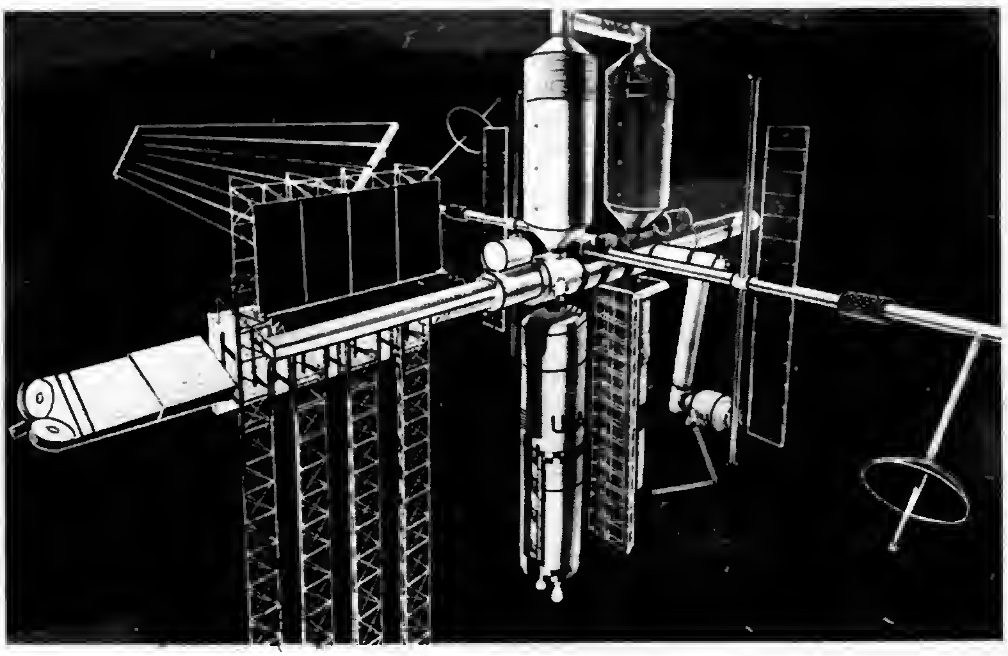
CHINESE SATELLITES

The Chinese made their first multiple-payload launch on 19 September when their CSL-2 booster put three satellites into a 1000 × 149 mile orbit.

All three (the 9th–11th Chinese satellites) are described as being space physics satellites. One consists of a balloon linked to a solid sphere.

NASA ANTENNAE CLOSED

Three 26 metre tracking antennae operated by the NASA Deep Space Network at Goldstone (California), Madrid (Spain)



An earlier concept of the Space Operations Center, a permanent manned low Earth orbit space station. The habitation modules and a propulsion stage are shown in the centre, while at left is a section manufacturing units for a Solar Power Satellite.

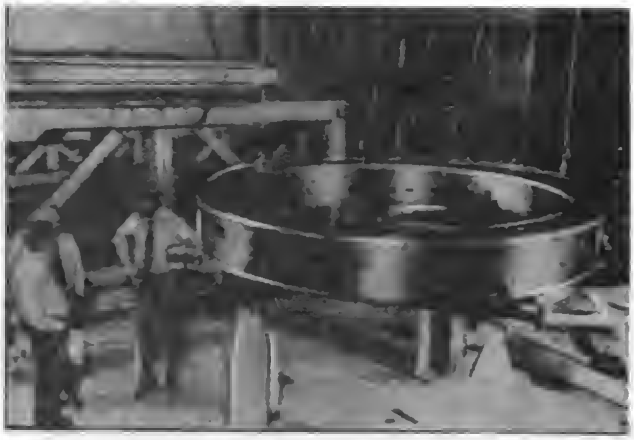
NASA

and Canberra (Australia) ceased operations on 1 December because of reductions in NASA's operating budget and the modestly declining workload of the network.

The stations will continue to operate 64 m and 34 m deep space tracking antennae as in the past.

Ending operation of the 26 m antennae will cause a reduction of about 30 percent of the Deep Space Network tracking and data-acquisition capability. This means less support for NASA planetary spacecraft: Voyagers 1 and 2, Helios 1, the Mars Viking 1 Lander and Pioneers 6 to 12.

It is estimated that terminating operations will result in savings of about $7.2 million per year beginning in Fiscal Year 1983.



The Space Telescope took a step closer to its scheduled 1985 launch when a major hardware section was delivered. The hardware is the Telescope's "main ring", a half-ton circle of titanium that houses the primary mirror. It was uncrated at Perkin-Elmer Corp., the prime contractor of the Optical Telescope Assembly, after shipment from a subcontractor.

During the 18 months of fabrication, the ring required precision machining and had to be made strong enough to tie together the major structural elements of the telescope. Thermal conductivity was an important consideration, since the primary mirror is to be maintained at "room temperature" – approximately 70°F – to avoid distortion of the image that the mirror will produce. Heaters will be mounted on the ring, which must easily transfer the heat to the mirror.

NASA

SOVIET-FRENCH SATELLITE

A new Soviet-French satellite for gamma-ray astronomy is planned for a 1982 launch from the Soviet Union, writes Joel Powell. As a follow-on to the Signe programme, the satellite, to be known as "GAMMA 1", will study gamma-ray sources with better angular resolution than available on previous satellites due to a "novel design." GAMMA 1 will perform observations of extragalactic sources and augment the work of ESA's COS-B gamma ray satellite, launched in 1975.

A cooperative programme of gamma-ray astronomy also exists between India and the Soviet Union. The GRIST (Gamma-Ray India Soviet Telescope) project has involved Soviet "Anna 6" and "Natalya 1" gamma telescopes launched by balloons from India. The next step will be to launch a joint India-USSR gamma-ray satellite from the Soviet Union in the near future. Using a "Natalya"-type telescope, the cooperative venture between Intercosmos and ISRO will be similar to the GAMMA 1 project with France.

THERMAL EXPLOSIONS

Research on the stratosphere over Arctic areas, has revealed sudden and sharp rises of temperature, writes Julian Popescu. According to the findings of radio probes, the temperature in the Arctic and Antarctic at altitudes of 50km may rise by as much as 40°C within a few hours. These thermal explosions form, as a rule, over geomagnetic areas and then move over vast distances regardless of weather conditions. Scientists explain this mysterious phenomenon as being caused by the interaction of corpuscular solar radiation with the Earth's magnetosphere. By correlating the timing of the thermal explosions with solar activity, Soviet scientists have found that temperature rises occur two or three days after flare-ups in the Sun's corona. The phenomenon is now regarded as a reliable indicator of magnetic storms and hence of subsequent weather disturbances on Earth.

SPACELAB 4 EXPERIMENTS

NASA's Office of Space Science has selected the principal investigators and payload science experiments for the first dedicated life science mission, Spacelab 4, scheduled to fly aboard the Shuttle in October 1985.

Twenty-five experiments were selected for the mission, which will study the biomedical problems associated with human spaceflight and the effects of micro-gravity on living systems. The goal is to obtain medical and biological data through carefully planned experiments conducted on living organisms throughout the mission.

The science breakdown shows that six of the experiments concern cardiovascular and cardiopulmonary studies, three concern vestibular studies, three concern renal and endocrine studies, three concern hematology studies, one concerns immunology, four concern muscle studies, one concerns bone studies and four concern general biological studies.

The Spacelab 4 mission will consist of a Spacelab double habitable module equipped with a spaceborne biological laboratory. Major portions of the laboratory are being built by the Ames Research Center and the Johnson Space Center.

IN THE PAST

25 years ago ....
The first firing of a Thor missile, on 25 January 1957, ended only 6in. above the pad in an explosion. Thor is still in use today as the first stage of the Delta rocket.

20 years ago ....
Mercury spacecraft no. 16 is delivered to the Cape on 16 January 1962 in preparation for Wally Schirra's flight the following October.

15 years ago ....
Grissom, White and Chaffee die in a flash fire aboard their Apollo 1 spacecraft during a static test on 27 January 1967.

10 years ago ....
Luna 20 is launched on 14 February 1972 to become the second unmanned spacecraft to return a soil sample from the Moon.

5 years ago ....
Space Shuttle *Enterprise* is towed 50 km overland on 31 January 1977 from the Rockwell plant to Dryden Flight Research Center to begin preparations for the Approach and Landing Test Programme.

D. J. SHAYLER

A BRIEF HISTORY OF THE VOYAGER PROJECT – Part 5

By Dr. J. K. Davies

Continued from the August-September 1981 issue

Preceding parts of this series described the evolution of the Voyager spacecraft and the successful flypasts of Jupiter in 1979. Eighteen months after passing Jupiter, Voyager 1 was approaching Saturn and at the conclusion of the first part of the far encounter sequence the spacecraft was only 10 days from closest approach.

Closing in

The second part of the far encounter II phase started 14 million kilometres from Saturn. At this time the spacecraft was 1,500 million km from Earth and the one-way radio communication time was 85 minutes, nearly 3 hours for a round trip. This phase would last until 26 hours before closest approach when the near encounter sequences stored in the onboard computer would take control of the spacecraft as it passed through Saturn's satellite system.

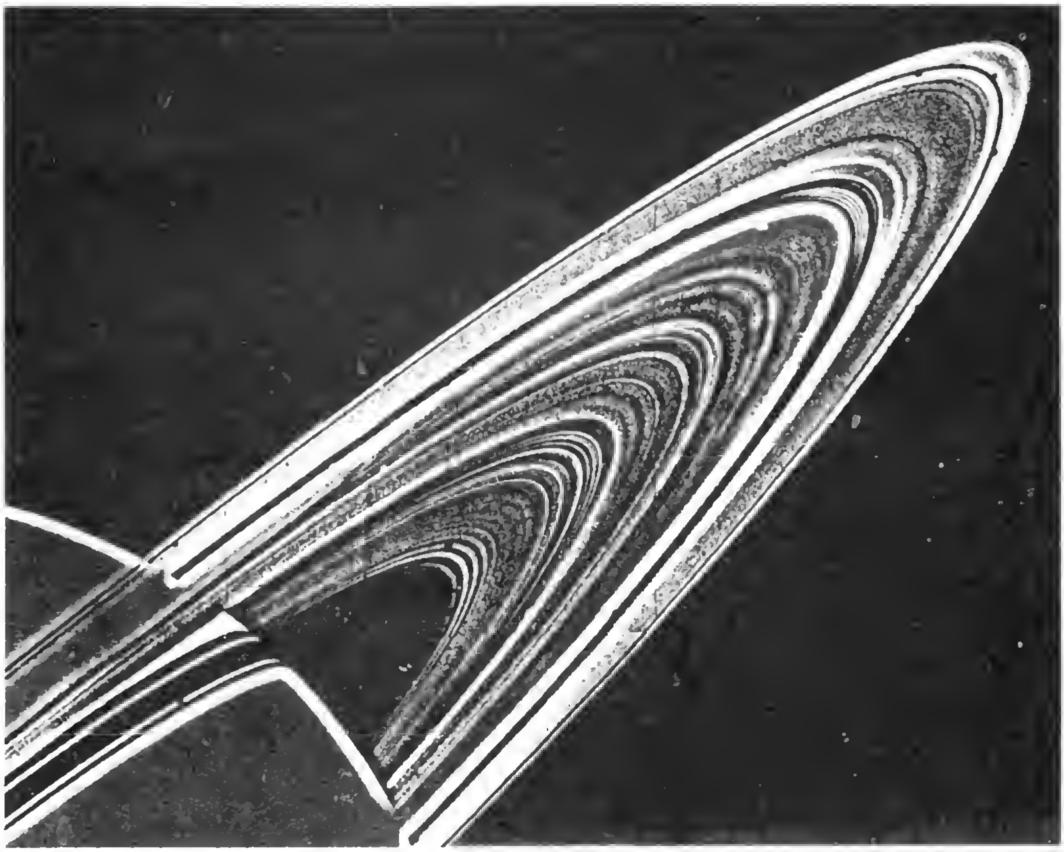
By now the angular size of Saturn had grown so large that 2 × 2 mosaics were no longer adequate to image the entire planet and the cameras were commanded to switch to 3 × 5 high resolution colour mosaics of the planet and its rings. Voyager 1 was approaching from above the ring plane and was planned to cross it just after its approach to the satellite Titan, 18 hours away from Saturn encounter.

As the picture resolution of the rings improved, another major surprise was in store for the scientists at Pasadena, because it was becoming obvious that the structure of the rings was far more complex than had been originally supposed. A two image mosaic of the ring system taken on 6 November, at a range of 8 million km, revealed nearly 100 individual concentric features in the rings. Saturn's rings looked remarkably like a cosmic gramophone record 275,000 km across. After two centuries of explaining how Saturn's rings were controlled by the well-understood gravitational influences of the major satellites, the astronomical community had only a few hours to prepare an explanation of why things hadn't quite turned out as expected, and Saturn was still five days away.

On 6 November the final course correction prior to Saturn encounter was made. This manoeuvre did not succeed in exactly aligning Voyager 1 with its planned trajectory but project officials said that Voyager's course was within mission requirements. Also on 6 November, a series of photographs was taken as part of a pre-planned survey of the space around the rings in the search for new satellites, and the discovery of moon number 15 was announced the following day. Detected at a range of 8 million km, satellite 15 orbits every 14 hours and 20 minutes, a mere 800 km from the outer edge of the A ring. It was thought that this tiny body, only about 100 km across, played a crucial role in defining the outer edge of the main ring system.

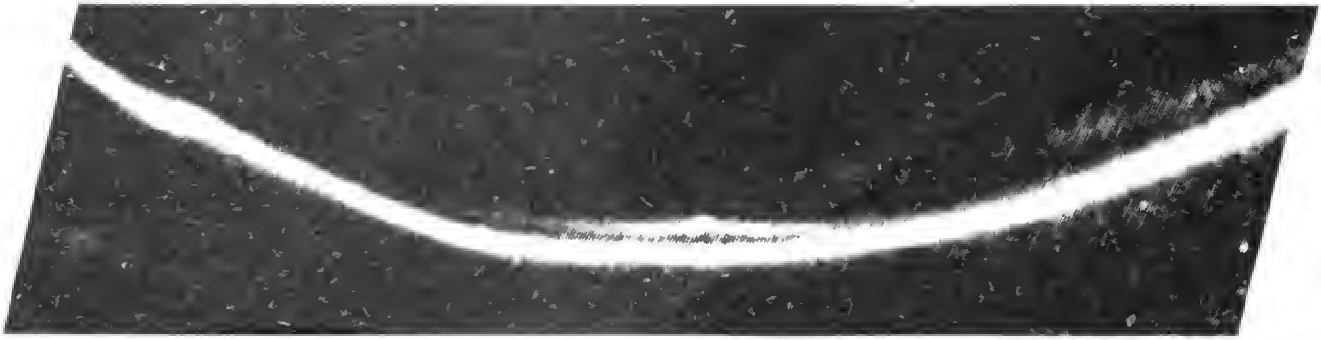
The Rain in Spain

Although the approach to Saturn was going extremely well, a minor problem was appearing back on Earth where heavy rain at the Deep Space Network tracking station near Madrid was threatening to interrupt X-band communications with Voyager 1. The X-band (5.2-10.9GHz) transmitters on the spacecraft are able to return data to Earth at a staggering 115.2 kilobits per second, but heavy rains near the Earth station where the signal is received can severely disrupt reception.



A two-image mosaic of Saturn's rings taken on 8 November 1980 (described in the text immediately above). Saturn's 14th satellite, discovered by Voyager 1, can be seen at upper right inside the barely-visible F-ring.

NASA



The braided F-ring, discovered by Pioneer 11, seen from the dark side at a range of 470,000 mi.

NASA

Data can still be returned by the S-band transmitters but the amount which can be transmitted is severely reduced.

On the night of 7-8 November a series of thunderstorms developed near the Madrid station and about 5 hours of data was lost. Mission scientists seemed not to be unduly concerned by this since most of the lost information would be repeated later and in more detail as Voyager closed with Saturn. The storms returned later in the week during the critical Earth-Titan occultation phase, but since the spacecraft was sending unmodulated signals as part of the occultation experiments there was no significant loss of data.

If X-band contact is lost at a critical phase it is possible to record the information on the spacecraft's tape recorders but this means that later observations must be sacrificed to allow the recorder's contents to be played back and transmitted to Earth.

Nearing the target

Two days from closest approach there was another surprise when Voyager 1 discovered two eccentric rings, unlike the usual circular ones. One of these lay within the innermost C ring, the other in Cassini's division. Dr. Brad Smith, head of the imaging team, said these rings were the feature he least expected to see. The following day he revised this opinion as Voyager returned pictures of the faint outer F ring (discovered by Pioneer 11), showing it to have three components, two of which appeared to cross like the strands of a rope. 'Obviously pure gravitational forces were not the only ones operating here,' Dr. Smith said, 'In this strange world of Saturn's rings, the bizarre has become commonplace.'

While attention focused on the rings, the detail visible on the planet had increased to objects as small as 175 km and small-scale convective clouds were being clearly seen. Simultaneously, the other experiments continued to probe the electromagnetic and particle fields around Saturn looking out for the bow shock as the solar wind interacted with the planet's magnetic field.

Voyager 1 crossed Saturn's bow shock on 11 November, a little over 1.5 million km from the planet and just prior to the start of the near encounter phase. Behind the bow shock was the turbulent boundary between the shock and Saturn's own co-rotating magnetic field. This area is known as the magnetosheath and in an hour Voyager 1 recorded no less than five crossings into and out of the magnetosheath as the exact boundary ebbed and flowed. Then Voyager turned its electronic senses towards its first major target within the Saturn system, the moon Titan.

The large crater on Mimas is 130 km in diameter with a prominent central peak. The abundance of small craters indicate an ancient surface.

NASA

The Sirens of Titan

Titan, Saturn's largest satellite, had drawn the attention of astronomers for decades because it is the only satellite in the Solar System known to have an atmosphere. Methane was detected in the atmosphere in 1944 and it has been cited recently as a possible abode of life.

On 11 November Voyager 1 closed in on Titan and the pictures received in Pasadena showed it to resemble a fuzzy yellow tennis ball with no observable features. Like Venus, the surface was covered in an impenetrable layer of haze. Fortunately, Voyager's senses were not limited to visible wavelengths and its infra-red, ultraviolet and radio occultation experiments were able to reveal several surprising new facts about this mysterious satellite.

Voyager 1 flew behind Titan on 11 November 1980 just 60 seconds from the planned time and less than 10 minutes after its closest approach. This Earth occultation allowed Voyager's radio experiments to probe the atmosphere and measure the satellite's diameter. Almost immediately Titan was dethroned as the Solar System's largest satellite, as radio measurements revealed its diameter to be about 5120 km, over 100 km less than Ganymede. Analysis of the atmosphere took a little longer to complete and the results were not announced until a few days later.

Titan's atmosphere was found to extend over 300 km into space with a dense optically opaque haze extending to 280 km, topped by two thinner haze layers. Surface pressure was about 50% greater than on Earth with a surface temperature of about 92K (−181°C). Chemical analysis of the atmosphere provided

another major surprise: the main component was discovered to be nitrogen and not methane as previously believed.

Titan was thus revealed to be a remarkable world, for near the surface pressure and temperatures are such that methane may exist as gas, liquid or solid, and near the poles the temperatures may be low enough to allow nitrogen to liquify. If men ever attempt a landing on Titan they may one day stand on the shores of a liquid nitrogen lake, while all around them the clouds gently rain flakes of methane snow.

While still behind Titan, Voyager 1 dipped below the plane of Saturn's rings and continued to close in on the planet, imaging the rings, the planet itself and its innermost moons.

The moons of Saturn

The result of the close flybys of Saturn's moons will not be given in great detail here since they are discussed in [1-6], but a brief summary will be given.

The next moon to be encountered, some 16 hours after passing Titan and only 90 minutes before Saturn closest approach, was Tethys. Tethys orbits 300,000 km from Saturn and would be on almost the opposite side of the planet from Voyager 1 so the minimum distance from the spacecraft was over 400,000 km. Even at this long range Voyager's cameras were able to take photographs showing that Tethys, roughly one third the size of Earth's Moon, was heavily cratered. The side of the satellite facing Saturn was scarred by a large fracture about 750 km long and 60 km wide. The absence of any evidence of cratering within this feature showed it to be relatively recent. The density of Tethys was found to be low, suggesting that it is composed mostly of water ice and that the cratering and the large fracture are probably the result of intensive bombardment.

Further evidence of significant impact cratering was discovered during Voyager's approach to Saturn, as a long range photograph of Mimas revealed a massive crater 130 km in diameter, nearly one quarter the diameter of the satellite.

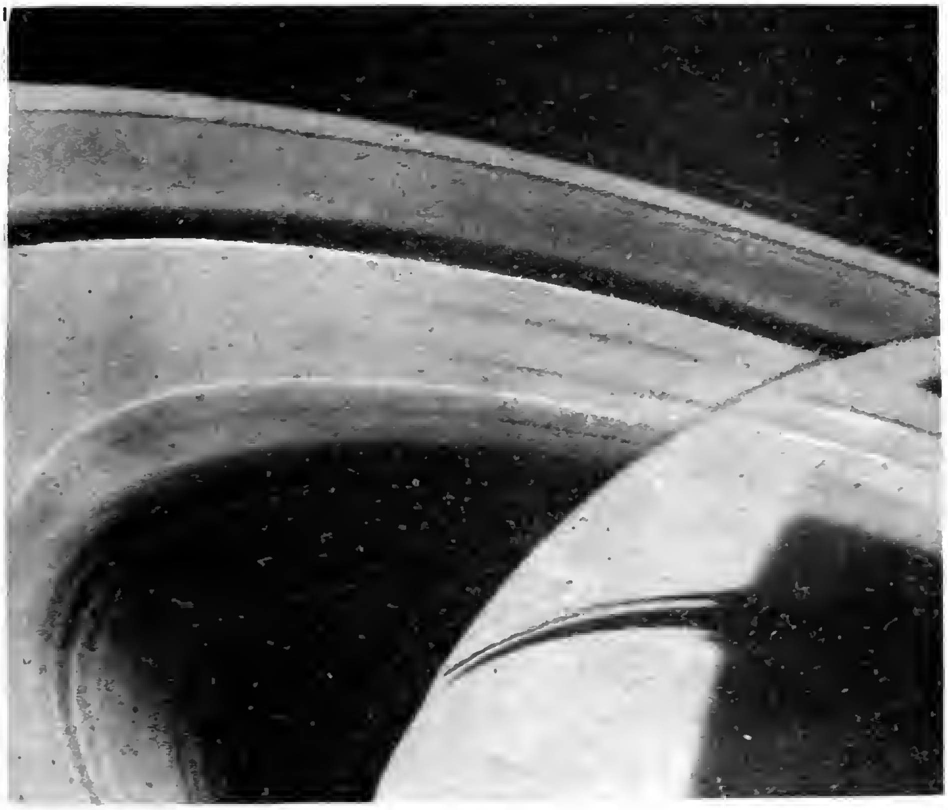
After passing by Tethys, Voyager 1's trajectory began to curve upwards again, back towards the ring plane so that as it made its closest approach to Saturn on 12 November it was on the ascending portion of its trajectory and heading for a close encounter with Mimas, the innermost classical satellite.

Voyager 1 passed within 108,000 km of Mimas and obtained high resolution photographs of the face which looks away from Saturn. This surface, like the opposite hemisphere, was heavily cratered and at the antipode of the massive crater observed on the approach, lines were detected, possibly related to the original impact. Dr. Eugene Shoemaker of the US Geological Survey speculated that had the impact been much more severe, Mimas would probably have disintegrated.

Minutes after passing Mimas, Voyager 1 made its closest approach to Enceladus. Enceladus was not a prime objective of this first probe and the miss distance was large, a little over 200,000 km. At this range the best surface resolution possible for Voyager's cameras was about 12 km and surprisingly, at least down to this scale, the surface appeared smooth with no evidence for cratering. Enceladus is locked in a 2:1 orbital resonance with Dione and this may lead to periodic stretching by Dione's gravitational field. The friction and tidal stresses caused by this stretching may liberate just enough heat to warm the icy body and smooth out its surface. Enceladus was one of the prime targets for Voyager 2, eight months behind its twin.

For 90 minutes during the close approaches to Mimas and Enceladus Voyager 1 was hidden from the Earth by the bulk of Saturn, allowing the usual radio experiments to probe the detailed structure of the planet's atmosphere. Shortly after emerging from behind Saturn, Voyager 1, as seen from Earth, began to pass behind the ring system and further radio and optical measurements were made to probe the density and composition of the rings.

Dione was the next moon to be encountered and a series of beautifully detailed photographs was returned to Earth showing a highly reflective, heavily cratered surface with several sinuous valleys and what appeared to be a large mare-like basin. Bright streaks were observed on the surface, probably ice ejected from relatively recent impacts which has



The planetary crescent, the A, B and C rings and their shadows are seen in this image taken on 13 November 1980.

NASA

not yet faded to the colour of the older surface. Dione is about 1110 km in diameter and its density is higher than the other inner moons, suggesting a higher proportion of rock, possibly as high as 60-70%.

With its trajectory still carrying it upward, Voyager 1 made a second crossing of the ring plane before turning its electronic eyes on Rhea, the second largest of Saturn's moons and the last body of any size Voyager 1 will pass close by for geological ages.

Rhea has a diameter of about 1500 km and Voyager 1 passed within 75,000 km of it, 6½ hours after closest approach to Saturn. Like Dione, the surface of Rhea is highly reflective with bright streaks overlying parts of the surface. Rhea is the most heavily cratered of all Saturn's satellites thus showing the extreme age of its surface, probably reflecting a cosmic bombardment about 4,000 million years ago. The largest crater observed by Voyager 1 has a diameter of about 300 km. Many of the craters show central peaks caused by the rebound of the floor after the explosion which formed the crater.

The Rings of Saturn

During its approach to the planet, Voyager 1 showed that Saturn's rings were far more complicated than had been previously believed. As the spacecraft dipped below the rings, viewing them from the unlit side and then climbing up and away from Saturn, many more pictures were received which shed important new light on their structure.

Classically, the main portions of the rings are known by letters, and reading from the centre of the planet outwards they are D, C, B, A, F and E. The irregular alphabetical sequence comes from the order in which they were discovered. Some of the significant Voyager findings about the rings are given here, in order of increasing distance from the planet.

The very faint D ring has been observed from Earth but its existence has long been disputed. Voyager 1 has confirmed that it does exist and shown that it stretches right down to the cloud tops.

Analysis of radio signals passing through the C ring gives an average size of the particles in the C ring as 2 metres.

During the approach to Saturn strange dark spokes had been observed in the B ring. These spokes did not follow the general rotation of particles within the ring, but dissipated a few hours after they emerged from Saturn's shadow. As Voyager 1 ducked below the rings, the dark spokes changed, appearing brighter than the surrounding material and this appearance was maintained as Voyager receded from Saturn. This shows that the particles must scatter light forward, rather than reflect it back towards the Sun. This in turn means that the particles are very small, similar in size to the wavelength of light. The spokes were observed to rotate at the same speed as Saturn's magnetic field, suggesting that the particles are actually levitated above the plane of the ring by electrostatic forces.

Cassini's division, which separates the B and A rings, was once believed to be empty, but Pioneer 11 showed that it actually contained some particulate matter and Voyager pictures revealed over 20 ringlets within it.

The A ring is the outermost of the well known rings and its outer edge appears to be controlled by the presence of tiny satellite 15.

The F ring was discovered by Pioneer 11 and Voyager 1 has shown that this ring consists of three interwoven ringlets, shepherded on either side by satellites 13 and 14. Within the three ringlets are clumps of material, short segments of increased density about 100 km long, their origin a mystery at present.

Further out still is the faint E ring, only visible from Earth when the rings are edge on, and possibly another ring between the E ring and the planet. This additional ring was discovered when its shadow was observed passing briefly across satellite 11.

Light scattering experiments showed that the particles in the D, E and F rings are small, mostly about 0.0002 mm in diameter. The composition of all of the rings is believed to be a mixture of ices and ice covered silicates, similar to the composition of interstellar dust.

Saturn

The planet itself is a much less colourful world than Jupiter, probably because it is 25 to 30 K colder, the temperature near the cloud tops being a chilly 97 K. This coldness means that the clouds on Saturn form lower in the atmosphere and appear muted by high level haze. Wind speeds, however, are up to four times faster than on Jupiter, reaching 1600 km/hour near the equator. Like Jupiter, Saturn has aurorae, oval atmospheric spots and lightning-like discharges, although these discharges are believed to occur in the rings, not the atmosphere.

For more details of the scientific results see [1-6].

Mission Accomplished

As Voyager 1 climbed away from Saturn in early November its sensors continued to study Saturn. Wide angle pictures taken during 16-18 November were assembled into another time lapse movie of the planet's rotation. Looking back at Saturn, Voyager produced some beautiful photographs of the crescent planet and its rings, as well as conducting infra-red, ultraviolet and radio astronomy observations. Imaging finally ceased just before Christmas 1980.

On 23 November the plasma instrument aboard the spacecraft stopped transmitting usable data, but was left on in the hope that ground controllers could reactivate it. A similar fault had disabled the instrument for three months earlier in the year. By 5 December Voyager 1 was 29 million km from Saturn and travelling at 21.6 km/s. Even though observations of Saturn were drawing to a close, Voyager would continue to study interplanetary space as it travelled towards the edge of the solar system.

The main part of its mission over, Voyager 1 will continue to transmit until contact is lost in perhaps another 10 years. By then it may have passed the heliopause, the boundary of the Sun's influence and be into truly interstellar space. Voyager 1 had succeeded beyond the dreams of its creators and was now irrevocably committed to deep space. Travelling roughly in the direction of the constellation Ophiuchus on a journey which will probably outlast the Earth itself, Voyager 1 will carry the sounds of the Earth to the stars.

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NEWS FROM THE CAPE

By Gordon L. Harris

FINANCIAL SQUEEZE

NASA may lose at least three planetary programmes in the Reagan Administration's drive to reduce Federal spending by another $13 billion in the current fiscal year.

Washington reports suggest the agency must accept a $350 million cut in Fiscal year 1982 which began 1 October 1981. Dropping the proposed mission to Halley's Comet, a radar probe to Venus (VOIR) and the Galileo mission to Jupiter would save about $800 million over the next two years. Administration sources talked of a $1 billion slice in 1983 and the same again in 1984. The FY 82 budget is $6 billion.

While Congressman Bill Nelson, the Democrat representing the Cape area, insists that more cuts will not affect employment at the launch site, a NASA spokesman pointed out that any reduction in space missions inevitably means fewer launches.

Even more may be at stake. News services quoted unnamed "Administration officials" who want to turn over NASA's space applications group to industry. This organisation is involved with communications, Earth resources and weather satellites.

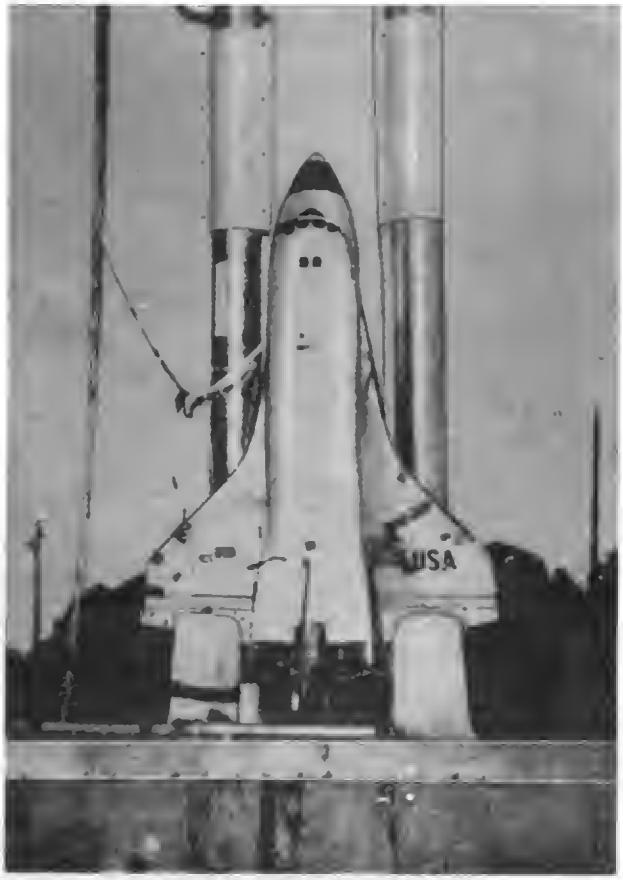
The same kind of turnover may also affect the agency's aeronautical research largely conducted at the Lewis and Langley Centers. That would leave NASA with the shuttle system and a worldwide tracking and data acquisition network.

Kennedy Space Center is known to have studied ways to relinquish more agency functions to industry and has indicated the change may occur as early as 1984. There would then be one contractor preparing shuttles for launch, another handling cargo and a third furnishing support services to both. Companies have been invited to send along representatives to observe the preparations for STS-3.

The invitation is an effort to give potential bidders every opportunity to learn what it takes to prepare the Shuttle for flight in order to assure knowledgeable competition when NASA solicits proposals for a Shuttle Processing Contract next autumn.

The Contract is the second of three comprehensive contracts that NASA intends to establish at Kennedy as the most effective and economical method of conducting Shuttle missions when the system becomes operational subsequent to the first four developmental flights. The first contract, covering base operations, or institutional support services, is scheduled to be awarded within the year. The third, the Cargo Processing Contract, is not currently scheduled but is intended to follow the other two.

Using the experience of industry representatives observing the processing of the Space Shuttle for its third mission, NASA plans to develop a statement of work for release next autumn. About nine months will be allowed for proposals, evaluation and negotiation of a new Shuttle processing contract. A six-month transition period is planned to permit orderly turnover after the contract is awarded in the summer of 1983. If the Schedule holds, the contractor will begin full operations at the beginning of 1984.



Columbia on the pad? No, this is a 1:6.4 scale model used at the Marshall Space Flight Center in Alabama to test solutions to a problem which became evident during the STS-1 launch. Several milliseconds after the solid boosters ignited, a pressure pulse four times greater than expected hit *Columbia*. No less than 37 firings of the model boosters were made before engineers settled on two solutions: spraying 100,000 gallons (US) of water per minute into the exhausts, and suspending water troughs underneath.

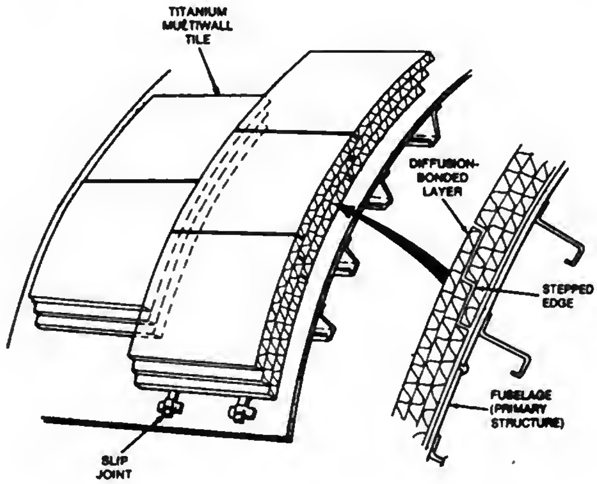
NASA

NEW SHUTTLE TILES?

One of the most troublesome Shuttle problems is installing and servicing the more than 30,000 silica tiles. A radically different thermal protection system has been devised by Robert Jackson of the Langley Research Center.

Jackson's solution consists of multiwall metallic panels capable of protecting Orbiters against temperatures ranging from 700 to 2,700 °F (3,700 to 1,480 °C). Each panel is attached to the primary structure with a bayonet mounting at its corners.

This simple slip joint allows for expansion. Felt strips are compressed at the panel edges and each panel is vented to local static pressure through a hole in the strip at its trailing edge on the cooler surface.



INDIA'S SLV-3 LAUNCH VEHICLE

By Neville Kidger

Introduction

Since its inception, in 1963, the Indian Space Programme has stressed two main aims:

1. The rapid development of mass communications and education, especially in widely dispersed rural areas.
2. Timely surveying and management of the country's natural resources.

In keeping with these aims, India has built three satellites for launch by other countries: Aryabhata, Bhaskara and Apple. The first two were launched in 1975 and 1979, respectively, from Kapustin Yar in the Soviet Union on the C-1 Interkosmos launch vehicle. Apple was given a free ride into space by the European Space Agency's Ariane L0-3 launcher on 19 June 1981.

While Aryabhata was basically a technological test satellite, Bhaskara has, since May 1980, been returning about 10 TV pictures per day of the Indian sub-continent for Earth resources studies, as well as performing other remote sensing activities.

Apple is designed to test the performance of an Indian-built 3-axis stabilised communications satellite stationed in Clarke (geostationary) orbit, and is the forerunner of the Insat 1 and 2 comsats currently being built for India by Ford Aerospace in the USA. Insats 1 and 2 will, following their launches in 1982 and 1983, respectively, provide comsat services for the country as well as conducting meteorological observations.

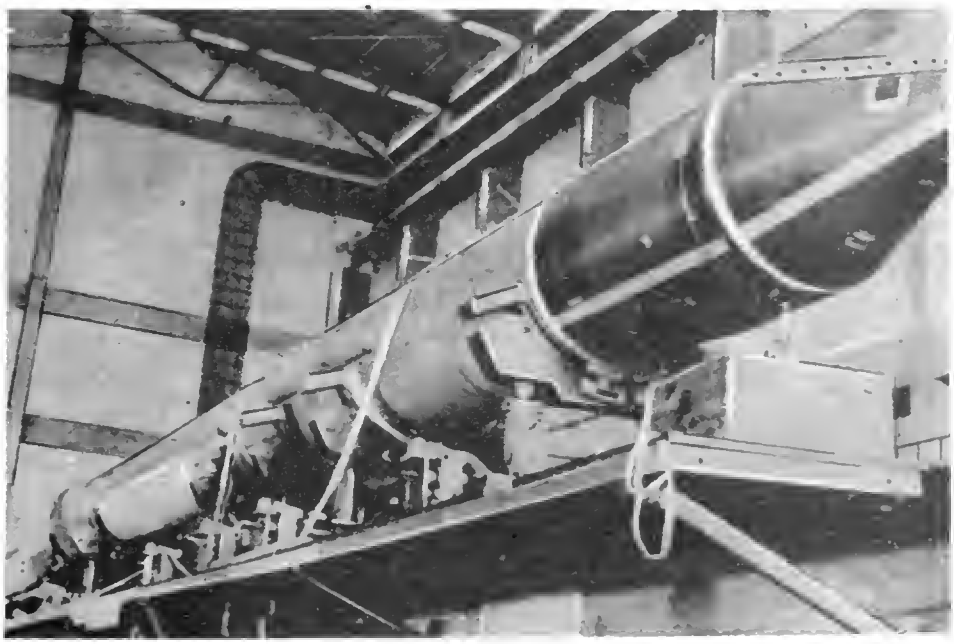
The SLV-3 launcher

While India has been accepting foreign aid to launch its satellites, ISRO (Indian Space Research Organisation) has been developing a national launcher which, in its final form, will be capable of launching 3.5 tonnes into low Earth orbit. The first steps in the programme have seen ISRO fly three of the first development launchers built under this programme – the SLV-3.

SLV-3 development began in 1973 with the intended objective of being able to place 40 kg into a 300 x 900 km orbit. The development programme has involved over 46 public and private industries working to develop the hardware and software for the SLV-3.

Launch of the first SLV-3, on 10 August 1979.

ISRO



An SLV-3 Launcher in final assembly.

ISRO

SLV-3 is a four stage solid propellant rocket 22.7 m high and 1 m in diameter. Take-off weight is about 17 tonnes. The first stage is 10 m long and is powered by a single 55,250 kgf thrust motor. The 6.4 m long second stage single motor has a thrust of 23,500 kgf. The third stage is 2.34 m long and is powered by a single 8,070 kgf thrust motor. The fourth stage motor has a maximum thrust of 2,150 kgf and the stage is 1.5 m long. Control of all stages is by inertial guidance.

More than 85% of the SLV-3's components were developed in India, including the solid propellants which are said to be comparable with any produced elsewhere. The first stage motor consists of three separate segments, reportedly for ease of manufacture, while the other stages have one-piece motors.

The SLV-3 contains 44 major systems, 250 sub-systems and 10,000 components.

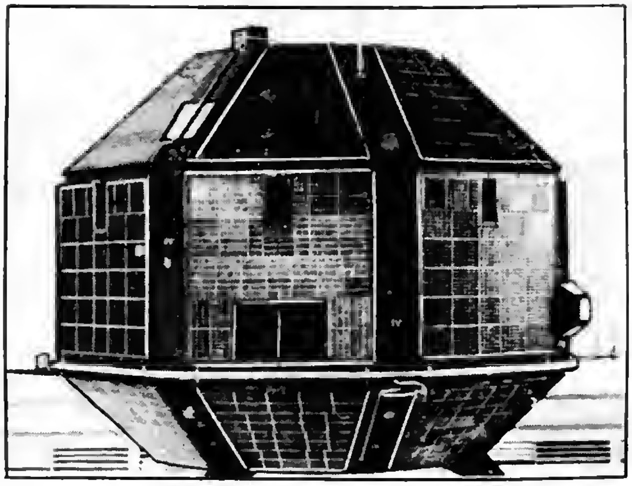
Payload for the three SLV-3s launched to July 1981 were small technological capsules called Rohini Satellite. The RS weighed 35 kg each, and were spin-stabilised polyhedral shaped capsules whose main function was the monitoring of the performance of the fourth stage of the SLV-3. Other objectives included evaluation of solar panel fabrication technology and of the Indian-made solar cells. The third RS also carried a small landmark camera for Earth observations. The camera, with sensors based on charged-coupled devices, collected data with a 1 km resolution.

The future

Currently, the Indians have not announced further plans to fly the SLV-3 launcher, despite the performance of the third flight. ISRO is now hoping to concentrate upon development of an advanced Augmented SLV (ASLV) which will use two strap-on boosters to increase the payload mass to 150 kg. Launch weight of the ASLV, which could fly in late 1982, will be about 39 tonnes.

Flight history

The first flight SLV-3 was launched on 10 August 1979 from the launch site at Sriharikota Island, north of Madras. The flight lasted for 317 seconds. Due to a second stage fault (caused by the malfunction of the control system when nitric acid in a solenoid valve drained off) insufficient velocity was attained to reach orbit and, despite the successful performance of over



India's second satellite, Bhaskara.

ISRO

70% of the SLV-3 systems, the rocket impacted in the Bay of Bengal some 500 km away from the launch site.

Following fixes to the next vehicle, the second SLV-3, launched 18 July 1980, successfully placed the RS-1 satellite into a 290 x 900 km orbit inclined at 45°. The solar cells developed 3W of electrical power and the satellite was reported to be spinning at a rate of 165 rpm. Tracking of the satellite was performed by the ISRO stations at Sriharikota, Car Nicobar, Thumba and Ahmedabad.

The third SLV-3 flight occurred on 31 May 1981 and placed the 38 kg RS-D-1 satellite into a lower orbit than planned – 181 x 364 km instead of 296 x 834 km – which resulted in the satellite re-entering the atmosphere and burning up on 9 June, after 130 revolutions. The lower orbit was apparently the result of anomalies occurring between the third stage separation and fourth stage firing.

Acknowledgements

The writer would like to thank Venkata Varada BS of the ISRO Satellite Centre for the photographs and information used to compile this article. In addition copies of *Flight International* and *New Scientist*, many dates, were used to compile flight data.

SALYUT 6 MISSION REPORT: Part 10

By Neville Kidger

Progress 12 In Space

At 1418 (all times GMT) on 24 January 1981 the USSR launched Progress 12 to dock with Salyut 6. This docking was accomplished at 1556 on 26 January with the rear docking unit of the station. Engineers at the Flight Control Centre (FCC) in Kaliningrad near Moscow then began the first of several important procedures which would see the station house its fifth long-stay crew.

At 1700 on 28 January the SKDU of the cargo ship was activated to raise the orbit of the complex to one with the parameters: height 307 × 359/km; period 90.9 minutes; inclination 51.68. Later, the Salyut's ODU propulsion system was automatically refuelled from the tanks aboard Progress.

A New Crew For Salyut

As Soviet specialists are happy to point out, no-one really anticipated that Salyut 6 would exhibit such an extended and productive life in Earth orbit. When the station was launched, its lifetime was estimated as being about 2 years. This would see a 3-month, 4.5 month and, with any luck, a 6-month long flight series.

That the Soviet Union was able, by the third anniversary of its launch, to fly four separate long-term crews for record duration stays and a further 8 crews (plus 1 failure) for shorter flights testified to the soundness of the design and the far-sightedness of the design principles embodied in it. It will be recalled that Konstantin Feoktistov, one of the chief designers of the vehicle, stated that Salyut 6, if properly supplied by Progress ferries, could remain usable in space for as long as 5 years (see the *Salyut 6 Space Station* in *Spaceflight*, April 1979).

According to *Aviation Week and Space Technology* (6 April 1981) the Soviet 5-year plan for 1981-85 excludes missions of a greater length than 6 months, scrapping of plans to replace Salyut 6 with Salyut 7 (although an East German report in April spoke of Salyut 7 being prepared for launching) and scrapping of plans to fly two Salyuts simultaneously.

It is anticipated, by this writer at least, that all future Salyut flights will feature three-man Soyuz T ships (Soviet sources have since said that Soyuz 40 was the last of the 'old' Soyuz craft — Ed). If this is so then it would explain why the Soviets flew a Salyut 6 veteran, Vladimir Kovalenok, and a newcomer to the cosmonaut corps, Viktor Savinykh (who only joined the cosmonaut detachment in 1978, after Salyut 6 had been launched) on a short-duration flight which had all the hallmarks of being flown to accommodate the two outstanding Interkosmos flights.

Kovalenok and Savinykh began joint training for the flight only 4 months before their launch in Soyuz T-4. According to Soviet statements, it takes about 1½ years to master the controls of a Soyuz T. Savinykh, a 41 year old geodesist, was involved in hardware design and flight control activities before his assignment to the Soyuz T-4 flight.

Problems With Salyut

Before Kovalenok and Savinykh could be launched, however, there appeared a new problem aboard Salyut. During the period of its autonomous flight, one of the station's three solar battery panels had become stuck, thus causing a reduction in the amount of power available aboard. FCC specialists spent two weeks troubleshooting the problem during which they altered the station's attitude to ensure habitable temperatures before they committed Soyuz T-4 to a launch. During this period the interior temperature dropped to 10°C, compared to the normal 19-21°C. This resulted in moisture forming on the interior walls. Soyuz T-4 carried equipment to repair this fault.

In place of the third crewman, Soyuz T-4 carried extra film and equipment. Shortly before the launch day the orbit of the Salyut/Progress complex was adjusted.

Launching And Flight Of Soyuz T-4

Soyuz T-4 was launched at 1900 on 12 March to initiate the new 5-year plan for spaceflights. Savinykh had the honour to become the world's 100th space traveller. Following the course corrections, carried out before Soyuz T-4 drifted out of view of the USSR land mass, the ferry ship was on an approach trajectory.

By late evening the next day (13 March) Soyuz T-4 was approaching the Salyut/Progress complex. By the docking orbit the accuracy of the approach, commanded by the BTsVK computer, was such that the computer advised the crew that it was stationkeeping so that docking would not occur outside of the zone of the tracking ships. The approach and docking manoeuvres were monitored by the *Kosmanavt Georgi Dobrovolski*, off the African coast, the *Kosmanavt Yuri Gagarin*, in the Straights of Gibraltar, and then by the tracking station in Yevpatoria, the Crimea. Over this last station, the BTsVK gave the command to dock and, at 2033, the two vehicles connected.

After checking the hermeticity between the vehicles, the crew crossed over into Salyut. Within hours of the transfer the cosmonauts had replaced the faulty solar battery orientation control, thus ensuring that power had been restored to normal. The temperature was stabilised at 20°C and pressure at 800 mm on the mercury column.

The Photons (the call sign of Kovalenok and Savinykh) spent the first three days of their flight activating the life-support, thermal regulation and other systems aboard the station. On the 14th they opened the hatch to Progress and began unloading the almost 1,200 kg of dry cargoes it had delivered. This cargo included regenerators, absorbers, food, repair equipment, scientific instruments, 200 kg of film, 200 kg of drinking water (transferred to Salyut's tanks *via* the Rodnik system).

The men adapted well to their new environment. Kovalenok, with his two previous flights to his credit, advised Savinykh on his adaptation. Medical checks were initiated as soon as the cosmonauts repaired their physical fitness trainer. Other immediate repairs were conducted to a condensate removal pump in the thermo-regulatory system; electrical currents in circuit boards were also measured. The cosmonauts also noted that the station was so full of equipment that they were having problems deciding where to store the *new* equipment. On 16 March the Progress 12 SKDU was used to raise the orbit of the complex to 339 × 353 km.

The cosmonauts activated several biological experiments almost as soon as they had settled into the station. They put seeds of the arabidopsis plant into the Fiton unit, which was equipped with a light source, and stocked up the Malakhit conservatory and magnitobiogravistat instrument in which they were to study the effects of a non-homogeneous magnetic field on the orientation of shoots of higher plants. Another in the series of experiments called resonance was conducted; a TV camera was also repaired.

Preparations For The New Crew

At 1814 on 19 March, to allow for the launch of the next international crew within the March window, Progress 12 was undocked. Salyut 6/Soyuz T-4 was left in a 345 × 358 km, 91.4

Vladimir Kovalyonok (left) and Viktor Savinykh in training at the Gagarin Cosmonaut Training Centre for the flight of Soyuz T-4.

Novosti

minute orbit, perfect for a manned launch.

At 1659 on 20 March the cargo ship's SKDU was activated for the final time to bring it down from orbit and its destruction during reentry over the Pacific Ocean. All was ready for the flight of the first cosmonaut from the People's Republic of Mongolia.

Soyuz 39 In Space

As normal for the international flights to Salyut 6, two crews had been trained for the flight. This time it was the turn of the Mongolians to have a representative in space. The prime crew consisted of Vladimir Dzhanibekov and Jugderdemidiyn Gurragcha, a 34 year old Captain in the Mongolian People's Army. The reserves were Vladimir Lyakhov, the veteran space traveller (who may now go on to command the Soviet/French flight in Spring 1982) and Maydarjaviyn Ganzorig of Mongolia.

Soyuz 39, carrying Dzhanibekov and Gurragcha ("Gurr" to his friends), was launched at 1459 on 22 March. It was the eve of the 60th Anniversary of the formation of the Mongolian People's Republic. The call sign of the crew was Pamir.

Upon learning of the launch, Gurragcha's father, in one of the quotes of the programme, said proudly "When my son was small he took part in horse races. I was proud of him, and wanted him to become a good horseman. Now he has saddled a spaceship."

By 1000 the next day, after the fourth orbit manoeuvre, Soyuz 39 was in an orbit with the parameters: height 271 x 320km; period 90.3 minutes; inclination 51.6°. The spacecraft had made 13 revolutions of the Earth.

During the early part of the flight, Dzhanibekov was affected by a rush of blood to the head which caused his image of himself to become distorted when he viewed himself in the mirror. This did not affect his work and soon passed.

From their intermediate approach orbit the Soyuz was manoeuvred over the next few hours to a docking with the Salyut station at 1628 over the Sea of Azov, just before orbital night-time. After the standard series of tests and checks the hatches were opened, 3 hours after the undocking, and the Pamirs crossed into Salyut where they were formally and warmly welcomed by the Photons. The crews swapped telegrams from the Soviet and Mongolian leaders, L. I. Brezhnev and Yu Tsedenbal.

Dzhanibekov said he was surprised at how the station had changed since his last visit. All of the free space aboard the station was now occupied with new instruments and equipment delivered by the cargo and transport ships.

During the stay of the Pamirs the two crews pursued their own programmes of research with the main crew being brought into the visitors' programme when the station needed orienting or equipment needed dismantling. The Pamirs filmed the Photons at work during their physical exercise routine.

During the week, the Photons conducted numerous experiments of their own including continuation of the biological experiments in the Vazon and Oasis units in which onions and peas had been planted. Barley seeds had been planted in the biogravistat unit. A hologram of a porthole, which had a micrometeoroid pit in it, was taken and shown to the Earth *via* the TV. The Photons conducted the resonance experiment in the continuing series of tests of the structural stability of the station. They also took samples of the air and microflora in the station for return to Earth with the Pamirs.

As usual on an Interkosmos flight, the visiting crew had a large and varied work programme. The Pamirs' programme encompassed about 30 experiments which are detailed below.

Earth Observation Experiments

Preparations for the flight of the first Mongolian to Salyut 6 were geared mainly to studies of Mongolia's natural resources. The territory of the MPR is vast with much of its barely-accessible regions hardly studied at all. Space technology is perhaps the most cost effective solution to the exploration of this territory.

In the ERDEM experiment a whole range of research and technological procedures were to survey Mongolia's natural resources with the aim of utilising them for the benefit of the national economy.

In the experiment, the territory of the MPR was photographed late in their stay on Salyut by the Pamirs with the MKF-6M and KATE-140 cameras while aerial photography and spectrometry of the same regions was conducted simultaneously by the USSR Academy of Science's AN-30 flying laboratory (equipped with an MKF-6M camera) and a GDR-equipped plane carrying GDR-made spectrometers. Ground-based studies of the same areas was conducted from mobile laboratories equipped and operated by Mongolian, GDR and Bulgarian specialists.

The tasks for the analysers of the data included studies of geological faults; mapping of areas under crops; updating of soil maps with areas of disturbed top soil especially noted; searches for subterranean water deposits; forest mapping and species identification; monitoring of air and water pollution. Areas of the GDR and the Baltic Sea were also photographed.

Using hand-held cameras and notebooks the Pamirs conducted the BIOSPHERE-MON experiment. This experiment required the cosmonauts to document observations of 14 assignments given them related to studies of natural objects in the MPR. Objectives of the study were:

- tectonics and structural interactions of the major fractures of the Khubsugul region;
- structure of the Ikhe Khairkhan ore-bearing zone;
- seismo-active zones;
- sighting and study of the ancient geological ring structures;
- crater-like structures and their patterns with respect to their natural spatial locations;
- peculiarities of the structure and formations of the granitoid massives;
- oil and gas-bearing zones;
- assessment of pasture lands for their condition and productivity;
- updating the boundary between the arid steppe and semi-desert regions in Central Mongolia;
- the Gobi Nature Reserve;
- arid regions prospective of subterranean water reserves;
- inventory of fresh water stocks locked in glaciers and updating the World Atlas of Glaciers;
- atmospheric processes;
- environmental pollution;
- detection of elemental phenomena.

Both sets of cosmonauts who trained for the flight received specialised training covering details of each assignment.

Astronomical Experiment

EMISSION. In this experiment dielectric detectors studied the flux and composition of cosmic ray nuclei under the energy of 10 MeV. A cosmic ray entered the detector and left a trace indicating its charge and energy. Dielectric detectors are simple and permit long exposure; they are unable, however, to record the time of impact. Mongolian-mined mica was included in their construction.

During the experiment (which lasted for just over 3 days) a detector was placed in the Lock Chamber exposed to open space, replacing the Splav-01 furnace, and another was left in the working compartment.

Dzhanibekov (left) and Gurragcha at the Gagarin Centre.

Mongolian Embassy

Mongolian scientists note that cosmic rays with charges of 2 to 28 constitute over 90% of the absorbed radiation dose on spaceflights. The experiment, which continued a similar Mongolian experiment on Interkosmos 6, is also expected to permit a search for elements not found in the Sun and measure the amount of cosmic ray flux at the time around the solar maximum period.

Atmospheric Experiments

The Pamirs continued the series of atmospheric observations begun on earlier flights; details as presented by Mongolian scientists are:

ILLUMINATOR. This experiment envisaged spectrometry of Salyut portholes to determine the extent of illumination intensity and state of glazing (due to dust, dirt, sweating and

frosting). Spectrographs were taken of the porthole under direct solar illumination and will be compared to previous results to determine the degree of degredation.

ATMOSPHERE. This experiment attempts, by spectrometry, to determine the amount of phase distortion when looking out of the station away from the nadir. The spectrographs are taken of several different phase angles.

HORIZON-DAWN. Spectrometry of the horizon at sunset and sunrise periods is used to determine the dispersed day-time atmospheric distortion. With angles under 10° of the solar submersion the visible radiation in the twilight zone, as well as on the sunshine side of the Earth at the height of 90-100km is defined by molecular and aerosol diffusion. Spectrometry isolates the basic components of visible radiation of the Earth's atmosphere.

TERMINATOR. Spectrographic recording of terminator regions is used to attempt a correlation with internal gravitational waves in the atmosphere.

CONTRAST. By taking spectrograms and photographs of the same area simultaneously it is possible to increase the amount of data which is extracted from multi-spectral data. The photographs and spectrographs of high contrast regions in the MPR helps to obtain a linear relationship between radiation and reflection and to use that relationship in the remaining portions of the spectrum and photographs of areas of unknown reflective property. High contrast areas used during the experiment were snow, sand, water and black areas. The method can also be used to spot polluted air. The spectrograms and photographs were simultaneously recorded with photographs of regions with MKF-6M between 10 a.m. and 5 p.m. local time.

POLARISATION. In this experiment, first conducted on Salyut 4, the visual polarisation of the ascending flux of sunlight re-emitted by the Earth's atmosphere was measured to find the correlation and dependence of the plane position and degree of polarisation on atmospheric-landscape situations. Specifically the cosmonauts had 3 tasks:

1) Definition of the plane position and measurement of the degree of polarisation in the direction of the nadir three times on the daylight semiturn side of the Earth (from terminator to terminator). The measurements were accompanied by simultaneous photography, in the direction of the nadir, by the KATE-140 camera for control purposes.

2) During the above, measurements were taken of atmospheric-landscape situations (cloud cover to non-cloud cover and *vice versa*) over diverse areas.

3) Incidental observations of visual light phenomena while measuring the plane position and degree of polarisation. Phenomena observed were: the zodiacal light, "whiskers" of the twilight segment and the aurora borealis.

The measurements were made with the Visual Polarisational Analyser (VPA-1M) instrument, modernised by Soviet and Mongolian specialists. The measurement of the plane position and degree of polarisation is completed in 2 minutes.

Multi-purpose signalling units USP-1 and USP-2 recorded parameters transmitted through telemetric links. USP-1 was specifically designed for the Polarisation experiment while USP-2 was used as a log-book for recording the parameters of different experiments and the independent power supply unit.

Mongolian scientists admit that few experimental data have been furnished by the VPA-1 instruments, hence the modernised version.

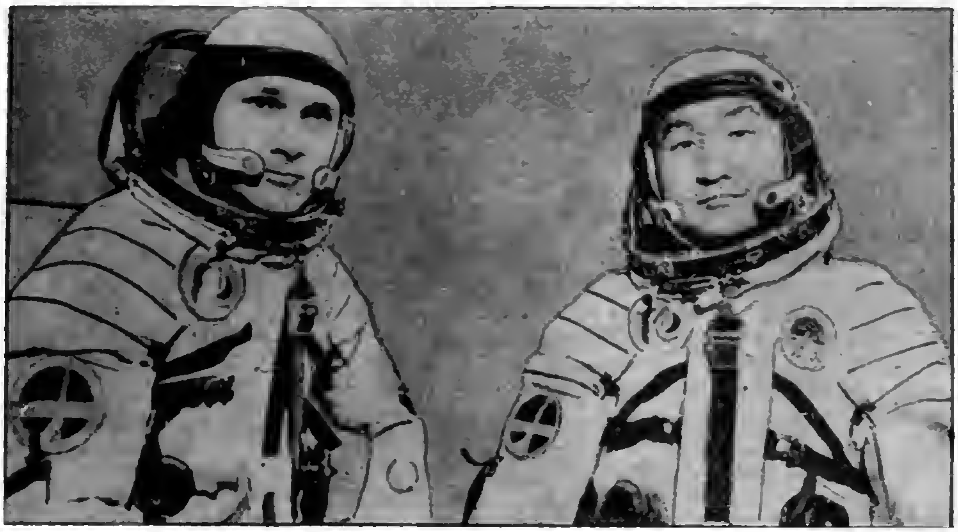
During the flight of Salyut 6/Soyuz T-4/Soyuz 39 over the MPR the two Mongolian tracking stations at Ulan Bator and the Gobi Desert were used to provide tracking information useful for geodetic studies.

Materials Processing Experiments

The Pamirs conducted three materials processing experiments during the final days of their flight. In order to use the Splav-01 furnace the Photons had to dismantle the Emission detectors and re-install the Splav in the Lock Chamber.

In the two smelting experiments they conducted, the Pamirs continued studies begun on the other Interkosmos flights. In the ALTAI-1 experiment the diffusion and mass transfer properties of two metals soluble in the liquid state and the effects of convective flows occurring in the gradient temperature field. The materials were lead and tin. Ampoules with these materials were placed in the Splav and heated, the first one to 300°C. A second ampoule was heated to 400°C and a third to a temperature between these two. Bars of lead and tin were sealed in a quartz ampoule with their highly polished flat surfaces pressed tightly together. The ampoules were then evacuated to 10^{-4} torr.

The ALTAI-2 experiment consisted of growing Vanium Pentoxide in microgravity conditions. The crystal is an active semiconductor crystal used in the production of thermistors. The space-grown crystals were expected to have a much



Soyuz 39 cosmonauts Dzhanibekov and Gurragcha.

Novosti

improved structure than their Earth-grown counterparts. The evacuated quartz ampoule was placed in the Splav furnace and heated to 700°C and, after a 2 to 3 hour pause, was cooled at a rate of 45°C/hour for one hour and then allowed to cool passively.

In the ERDENET (named for the Soviet/Mongolian copper combine) experiment the process of diffusion and redistribution of impurities while dissolving in water and crystallisation of copper sulphite was studied. The experiment was conducted in the food heater where glass ampoules were heated to 90°C then allowed to cool. The experiment is expected to produce methods to produce exceptionally high quality cleaning materials when recrystallisation occurs in weightless conditions. The dissolution process was recorded on film.

Medical Experiments

The major medical experiment conducted during the Pamirs' flight was BIORHYTHM which commenced before the launch with the establishment of baseline medical parameters for both cosmonauts. This was the first time that psychological and biochemical studies on a daily basis had been made of a Mongolian citizen (these baselines began to be established during the selection period in 1977). The parameters measured included Gurragcha's temperature, blood pressure, heart contraction rate and other parameters. Measurement of these parameters was conducted every 2 hours on the ground and in space. Any deviations noted in these measurements once in space were, naturally, induced by weightlessness.

Using the Timer Meditsinski and ET-01 electric thermometer and pulsotaxometer (to measure the systole rate) physicians at FCC monitored Gurragcha. Typical data for one day of the flight, March 29, showed that in the course of 24 hours Gurragcha's condition did not alter substantially from those recorded on Earth. His body temperature fluctuated between 35-36.2°C and his heart contraction rate varied between 62-68 beats/min. Arterial pressure was between 117-124mm maximum and 78-84mm minimum, again within the limits.

In the BLOOD CIRCULATION-SPRINT experiment the influence of the redistribution of blood in the body and the function of the cardiovascular and respiratory systems were measured while Gurragcha was performing exercises on the VTL-3 veloergometer under a measured load. Measurement devices were the GDR-made Pneumotest 78 and the USSR-made Polynom 2M, Beta 3 and Reograph 2 instruments. During 5 minutes of pedalling on the VLT-3 Gurragcha performed 750kg/m of work in one minute. It was determined that no changes had taken place in either him, or Dzhanibekov, when they performed the test.

Determination of the origin of space motion sickness, and a possible method to avoid it, provided the rationale for the PCSA experiment in which a Mongolian-designed device, called the Prophylactic Cervical Shock Absorber (PCSA), was worn by the Pamirs. The PCSA exerted artificial pressure on the cervical part of the spinal column to simulate gravity and restrict head movements in the period of acute adaptation to weightlessness.

The PCSA was worn throughout the first three days of the flight, except when sleeping, and for 30 minutes on the 6th and 8th days of the flight. Indices, such as EOGs, were recorded with the Aelita instrument while the cosmonauts made notes of his own assessment of his resistance to motion sickness.

In the FUNCTIONAL ABILITY experiment the cosmonauts had their sensory and motor reactions tested by between 16 and 64 irritants each switched on for different periods during which the subject had to give complex responses to differing combinations of visual irritants. The tests were repeated with acoustic irritants fed through earphones. The subject had to count short audio signals while conducting the main test and enter all data in the log book.

Other experiments, which continued earlier Interkosmos experiments, were the PERCEPTION experiment, in which the cosmonauts used the Cuban-made Contact device to measure their sensory function; the TIME experiment tested the cosmonauts' perception of time in space by means of the Rula instrument which was designed in the GDR. In this test the cosmonaut had to reproduce, at 10 sec intervals a sound which was recorded and compared with the actual time which had passed. In the QUESTIONNAIRE experiment the cosmonauts continued the series of question-answering tests with some new questions added by Mongolian specialists, who called this part of the experiment INQUIRY. The REST or Leisure experiment was continued in which the cosmonauts, during their off-duty hours, watched specially recorded VTR shows with cultural scenes designed to relax the viewer. Results of previous experiments in the series have shown that the main station crew have derived benefit in optimising their work performance as a result of these shows. Finally, the NEPTUNE experiment studied changes in the acuity and depth of the cosmonaut's eyesight during the flight, and the effects of a Mongolian-made drug were evaluated to assess the effect it had on the cosmonauts' daily rhythm.

Pamirs Return To Earth

On the 29th of March the working day of the Pamirs was reduced by two hours to allow them time for the correct amount of sleep to be fresh for their return to Earth the next day. To prepare for the return the Photons packed some of the results of their experiments into containers. The Pamirs would deliver these to Earth.

Tadpoles were packed into three containers; they had been used to study the vestibular apparatus of aquatic animals and were very lively. Samples of the chlorella plant, grown for 18 days, were packed into ampoules. The algae had developed well. Finally, orchid shoots were also packed away for return.

At about 0822 on 30 March, Soyuz 39 and Salyut6/Soyuz T-4 parted company. Retrofire occurred at 1051 after which Gurragcha reported a successful burn of the SKDU for the planned period. Separation of the modules occurred at 1117. Once through the atmosphere the main parachute was unfurled at an altitude of 7,000m. The landing occurred at 1142 some 170km SE of Dzhezkazgan. There was light fog and drizzle at the scene of the landing but the capsule, spotted as soon as the parachute opened, was followed down by the rescue helicopters and they touched down at the same time as the capsule. The two cosmonauts were quickly outside resting in the lounge seats provided for them. Gurragcha later described in excited terms the appearance of a blue flame around the cabin as the Soyuz entered the densest layer of the atmosphere.

The cosmonauts were flown to Baikonur where they were welcomed by the traditional bread and salt ceremony. They were both awarded several Soviet and Mongolian awards.

REFERENCES AND ACKNOWLEDGEMENTS

Sources used in the compilation of this report were (alphabetically): *Aviation Week and Space Technology*, *Aviatsiya i Kosmanavtika*, *BBC Summary of World Broadcasts* (section D), *Izvestiya*, *Letectvi i Kosmanautika*, *Moscow News* and *Moscow News Information*, *Pravda*, *Soviet Weekly*, *Zemlya i Vsellnaya*. In addition, materials made available by the Novosti Press Agency and the author's own monitoring of short wave news broadcasts in English by Radio Moscow World Service (and to North America) and the Voice of America also proved invaluable.

The author would also like to express grateful thanks to the staff of the Mongolian Embassy in London for help in the compilation of this section of the report.

MEDICAL DEMONSTRATION

One of the Marisat communications satellites was used during the Second Annual Washington Heart Ball (the proceeds of which go to the American Heart Association) on 7 November to demonstrate the techniques of remote medical care. A real-time electrocardiogram (ECG) was sent from a healthy volunteer crew member in the intensive care unit on board the ship SS Rotterdam to an electrocardiogram unit and display screens at the Ball. The Rotterdam was approximately 1000 miles from Washington, D.C. at the time of the demonstration.

The signal was transmitted from the Rotterdam, *via* a Marisat satellite, to a satellite Earth station in Southbury, Connecticut, from where it was sent by land lines to the site of the Ball. The connection was made by an automatic, unassisted telephone call placed from the Rotterdam. In this way, the ship's medical doctor was in instantaneous contact with doctors at the Ball concurrent with the transmission of the ECG. Doctors in Washington, D.C. and on board the Rotterdam could thereby be in real-time consultation, providing immediate service to the patient.

NAVSTAR UK STUDY

A study by Ferranti has been completed into the UK uses of the Navstar Global Positioning System (GPS) presently under development in the US.

The applications envisaged for Navstar include: precision weapons delivery; en-route navigation for space, air, land and sea vehicles; aircraft runway approach; photomapping; geodetic surveys; aerial rendezvous/refueling; tactical missile navigation system up-dating; air traffic control; range instrumentation and safety, as well as search and rescue operations.

Navstar is a satellite-based, universal positioning and navigation system, designed to provide precise 3-dimensional navigation information. It is planned to be operational in 1985 with, eventually, 18 satellites circling the Earth, probably in three orbits – six per orbit – giving global coverage under all weather conditions.

With a GPS receiver a user can process the signals transmitted by the satellites and determine his position within tens of feet, velocity within a fraction of a mile per hour, and the time within a millionth of a second. It is expected that a single Navstar receiver aboard an aircraft could achieve or surpass the capabilities of many of the current navigation aids, and at a lower equipment cost.

NEW OSCAR SATELLITE

The amateur radio satellite AMSAT Phase IIIB, which will become Oscar 10 in orbit, has been scheduled for launch in 1982, writes Joel Powell. The sophisticated new amateur radio satellite will be launched piggyback on ESA's Ariane L07 vehicle which will place the Exosat astronomical satellite into space. The first Phase III Oscar lies at the bottom of the Atlantic because of the launch failure of the second Ariane rocket in May 1980.

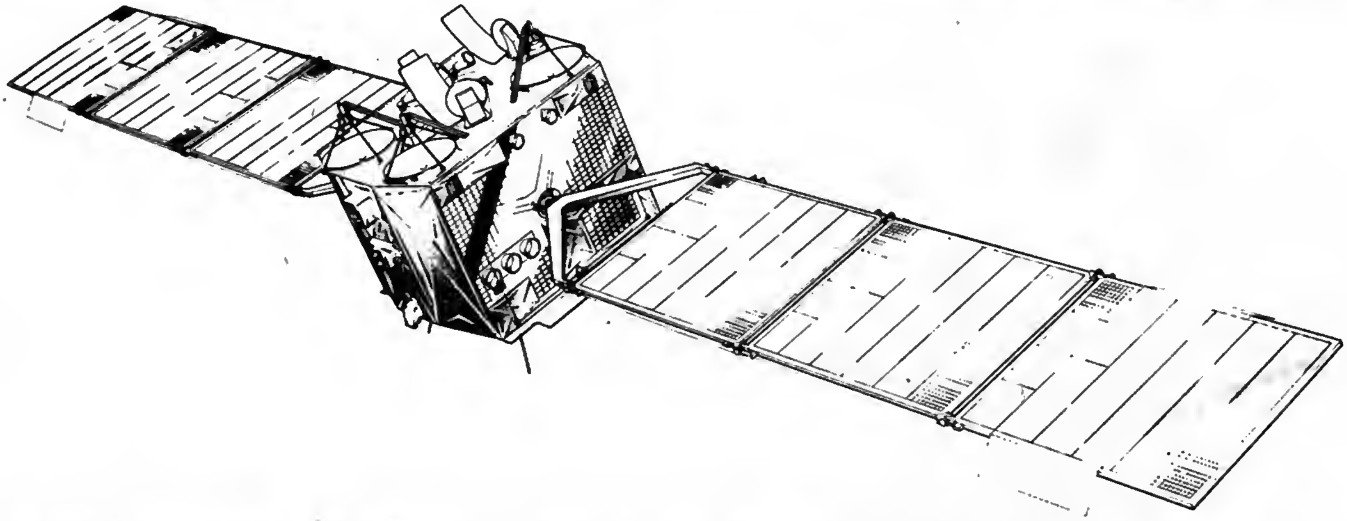
The tricornered satellite will provide a communication range of at least 17,600 km (11,000 mi) for 17 hours per day from its high altitude elliptical orbit. Oscar will transmit on the 435 MHz amateur radio satellite band with a 50 watt transponder; downlink is 145.9 MHz. Highly reliable two way communications, opportunity for long duration calls and increased VHF and UHF amateur bands efficiency will result from the orbiting of Oscar 10. For public service, the satellite offers increased emergency communications for disaster relief and the capability to transmit educational programming directly to school classrooms.

On-board housekeeping, telemetry and tele-command functions will be handled by microcomputer.

AMATEUR SYNCHRONOUS SATCOMS

AMSAT Corporation are planning the next step in amateur space radio – SYNCART (Synchronous Amateur Radio Transponder), writes Joel Powell. Low power radio transponders will be installed on commercial Clarke-orbit communications satellites. The transponder frequencies planned are 1,269 MHz uplink and 436 MHz downlink (called "Mode M").

SYNCART will extend the services of the Phase III Oscar satellites dramatically. Emergency, educational and two-way long distance communication will be expanded to around-the-clock operation on two SYNCARTS with no blockage by mountainous areas or of line-of-sight/satellite availability (as with Phase II Oscars). It is expected that the system can cover the entire Earth by using three satellites with radio interlinking.



The first ECS communications satellite, designed for European regional use, will be launched this year by Ariane. Each satellite will be able to handle 12,000 simultaneous telephone calls and two TV channels. The first Maritime version of ECS, MARECS, was launched last December by Ariane L04.

British Aerospace

SATELLITE DIGEST – 151

Robert D. Christy
Continued from the January issue

A monthly listing of satellite and spacecraft launches, compiled from open sources.

The heading to each launch gives the name of the craft, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes.

COSMOS 1285 1981-71A, 12627

Launched: 0012, 4 Aug 1981 from Plesetsk by A-2-e.
Spacecraft data: Possibly based on the Molniya design of a cylindrical body, surmounted by a conical motor section, and with power supplied by a "windmill" of six solar panels. Overall length around 4 m, and diameter 1.6 m, mass around 2,000 kg.
Mission: Probably part of the USSR's system of missile launch early warning satellites.
Orbit: Initially a low parking orbit and then injected into a highly elliptical orbit of 587 x 40429 km, 727.56 min, 62.95 degrees inclination.

COSMOS 1286 1981-72A, 12631

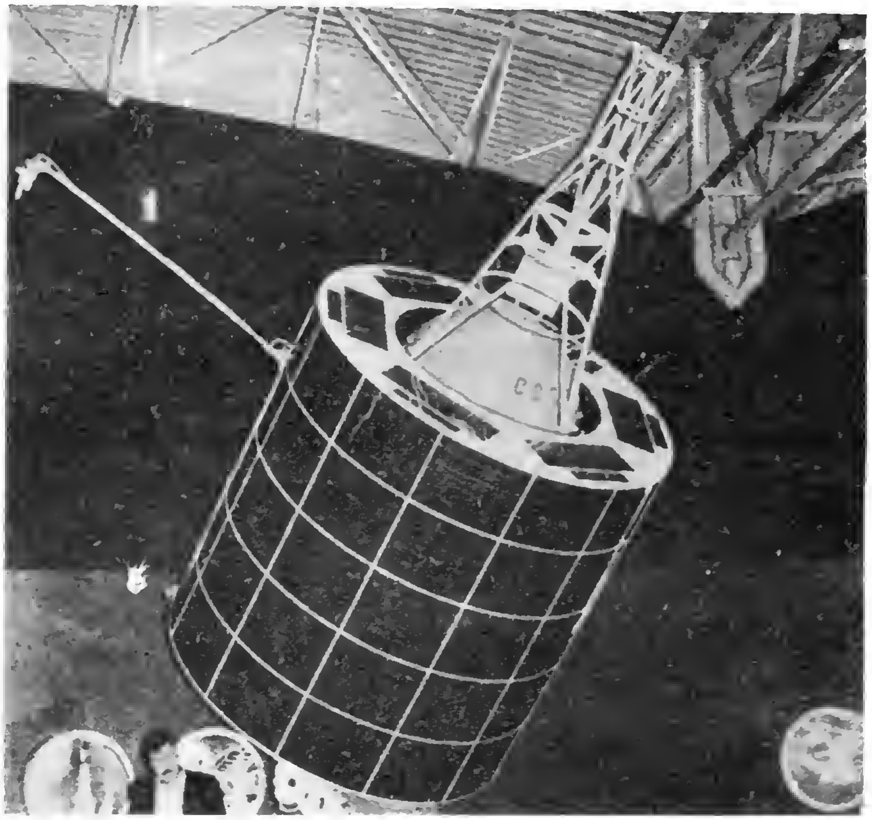
Launched: 0826, 4 Aug 1981 from Tyuratam by F-1.
Spacecraft data: No details available, probably several tonnes mass.
Mission: Probably an ocean surveillance satellite carrying out electronic reconnaissance, replacing Cosmos 1220 (1980-89A).
Orbit: Initially 431 x 444 km, 93.33 mins, 65.04 degrees, maintained at this height by a low thrust motor to ensure that its ground tracks lie half way between those of Cosmos 1260 (1981-28A).

FLTSATCOM 5 1981-73A, 12635

Launched: 0810, 6 Aug 1981 from Eastern Space and Missile Centre by Atlas Centaur.
Spacecraft data: Built by TRW for the US Department of Defense, FLTSATCOM is a hexagonal cylinder – 1.27 m long and 2.3 m diameter. Power is provided by a two solar panel array giving at least 1250 watts output over the vehicle's design life of 5 years. Communications are through a 3.75 m long helix antenna and a 4.9 m diameter dish operating at UHF frequencies, and an S band horn antenna. Stabilisation is by a combination of momentum wheels and low thrust motors. The orbiting mass is 1000 kg.
Mission: To provide S band and UHF communication between US military forces through 23 channels, and using relatively small ground equipment.
Orbit: Placed into geostationary transfer orbit by the launch vehicle, injected into geostationary drift orbit by onboard motor and stabilised at 92 degrees west.

COSMOS 1287-1294 1981-74A-H, 12636-12643

Launched: 1148, 6 Aug 1981 from Plesetsk by C-1.
Spacecraft data: Probably spheroidal in shape, mass about 40 kg each.
Mission: To provide tactical communications between troops or units in the field. The previous launch in the series was 1981-22.
Orbits: Lowest – 1393 x 1465 km, 114.46 min, 74.03 degrees; highest – 1465 x 1514 km, 115.79 min, 74.03 degrees.



The Soviet Union operates a satellite-based navigation system with several working satellites at any one time. Although it has been in existence for a number of years, it was not until 1978 that a satellite (Cosmos 1000) was described specifically as being part of the system. Cosmos 1295 was a routine, replacement launch into the system known as "Cicada" (because of the insect chorus-like sound of the orbiting radio beacons).

Robert Christy

INTERCOSMOS-BULGARIA 1300 1981-75A, 12645

Launched: 1130, 7 Aug 1981 from Plesetsk by A-1.
Spacecraft data: Based on the standard Meteor satellite body, it is a cylinder about 5 m long, 1.5 m maximum diameter, mass around 2 tonnes including over 350 kg of scientific instruments. Power is provided by a two panel, Sun tracking solar array.
Mission: To study the physical processes in the ionosphere and magnetosphere. This vehicle is the second launch under the Bulgaria 1300 programme (see also Meteor Priroda, 1981-65A). Instruments include photometers for producing spectra and photographs of the aurorae, UV and proton spectrometers, and a laser reflector.
Orbit: 799 x 893 km, 101.90 mins, 81.22 degrees.

HIMAWARI 2 1981-76A, 12677

Launched: 2010, 10 Aug 1981 from Tanegashima by N-2.
Spacecraft data: Cylindrical, spin stabilised vehicle with de-spun antennae and meteorological sensors. Diameter is 2.10 m, length 4.40 m, and the mass about 340 kg.
Mission: To improve the Japanese meteorological service and to develop meteorological satellite technology.
Orbit: Placed into geostationary transfer orbit by the launch vehicle, then to a geostationary drift orbit for final stabilisation above 140 degrees east longitude.

COSMOS 1295 1981-77A, 12681

Launched: 0546, 12 Aug 1981 from Plesetsk by C-1.
Spacecraft data: Cylindrical body with domed ends, enclosed in drum shaped solar array, with length and diameter both about 2 m. The mass may be around 700 kg.
Mission: Navigation satellite replacing or providing back up for Cosmos 1181 (1980-39A).
Orbit: 950 x 1014 km, 104.77 min, 82.92 degrees.

COSMOS 1296 1981-78A, 12687

Launched: 1619, 13 Aug 1981 from Plesetsk by A-2.
Spacecraft data: Possibly based on Vostok manned spacecraft with spherical re-entry module, instrument unit and a cylindrical, supplementary payload at the forward end. Length about 6 m, max diameter about 2.4 m, mass around 6000 kg.
Mission: Military photo-reconnaissance, recovered after 30 days.
Orbit: Initially 171 x 353 km, 89.77 min, 67.14 degrees, then manoeuvred several times to provide coverage of particular target areas.

COSMOS 1297 1981-79A, 12716

Launched: 0929, 18 Aug 1981 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1296.
Mission: Military photo-reconnaissance, recovered after 12 days.
Orbit: Initially 197 x 363 km, 90.15 min, 72.85 degrees, then manoeuvred on the second day to 225 x 304 km, 89.85 min, 72.86 degrees, and on the ninth day to 223 x 247 km, 89.25 min, 72.84 degrees.

COSMOS 1298 1981-80A, 12776

Launched: 1020, 21 Aug 1981 from Tyuratam by A-2.
Spacecraft data: As Cosmos 1296.
Mission: Military photo-reconnaissance, recovered after 42 days.
Orbit: Initially, 172 x 330 km, 89.57 min, 64.92 degrees, then manoeuvred several times to provide coverage of particular target areas.

COSMOS 1299 1981-81A, 12783

Launched: 1635, 24 Aug 1981 from Tyuratam by F-1.
Spacecraft data: No details available, probably several tonnes mass.
Mission: Ocean surveillance by radar, powered by nuclear reactor, terminated on 5 Sep after 12 days.
Orbit: Initially 247 x 266 km, 89.64 min, 65.01 degrees, then maintained by low thrust motor. Nuclear reactor boosted to 103 min circular orbit on 5 Sep.

COSMOS 1300 1981-82A, 12785

Launched: 2141, 24 Aug 1981 from Plesetsk by F-1.
Spacecraft data: Not available.
Mission: Electronic reconnaissance?
Orbit: 636 x 664 km, 97.78 min, 82.50 degrees, similar to the orbits of Cosmos 1076 (1979-11A) and Cosmos 1151(1980-5A) which were oceanographic study satellites.

COSMOS 1301 1981-83A, 12788

Launched: 1030, 27 Aug 1981 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1296.
Mission: Possibly military photo-reconnaissance, part or all of the payload was an Earth resources package, recovered after 14 days.
Orbit: Initially 213 x 271 km, 89.39 min, 82.32 degrees, but manoeuvred to 268 x 276 km, 89.99 min, 82.31 degrees on the second day of the flight.

COSMOS 1302 1981-84A, 12791

Launched: 1621, 28 Aug 1981 from Plesetsk by C-1.
Spacecraft data: Not available but may be similar to Cosmos 1295.
Mission: Military communications using store/dump technique, replacement or back up for Cosmos 1269 (1981-41A).
Orbit: 781 x 810 km, 100.82 min, 74.03 degrees.

OPS 3984 1981-85A, 12799

Launched: 1831, 3 Sep 1981 from Western Space and Missile Centre by Titan 3D.
Spacecraft data: Cylinder with antennae and solar panels, mass around 13000 kg, length 15 m and diameter 3 m.
Mission: Military photo-reconnaissance providing real-time transmission of television images. Replacement for 1978-60A which was de-orbited around 23 Aug 1981. OPS 3984 is one of the KH-11 series of satellites.
Orbits: Sun synchronous, initially 242 x 525 km, 92.27 min, 96.98 degrees – maintained or altered by an onboard engine.

COSMOS 1303 1981-86A, 12801

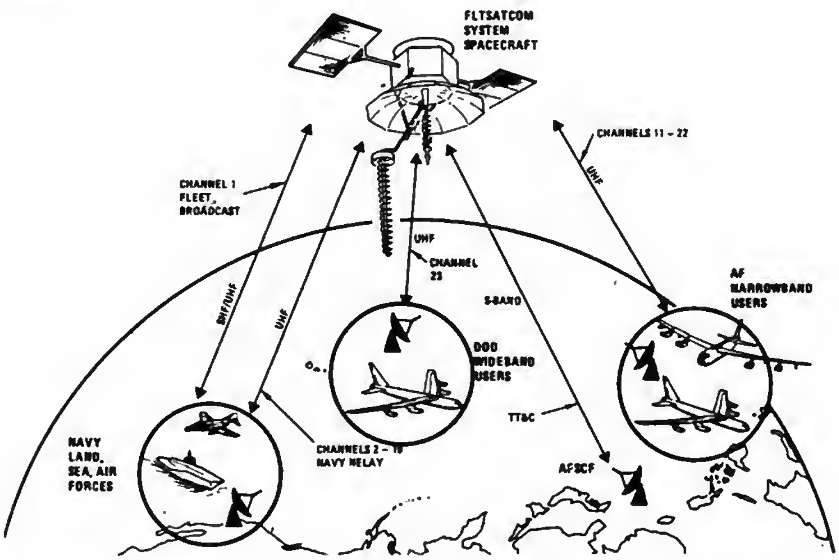
Launched: 0800, 4 Sep 1981 from Tyuratam by A-2.
Spacecraft data: As Cosmos 1296.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: Initially 206 x 375 km, 90.36 min, 70.41 degrees, but manoeuvred on second day to 360 x 415 km, 92.34 min, 70.41 degrees. Orbit maintained by small thrusts to ensure constant spacing between equivalent ground tracks on successive days.

COSMOS 1304 1981-87A, 12803

Launched: 1106, 4 Sep 1981 from Plesestk by C-1.
Spacecraft data: Not available, but may be similar to Cosmos 1295.
Mission: Probably a navigation satellite but may be part of another applications programme.
Orbit: 911 x 978 km, 103.97 min, 89.94 degrees – slightly lower than normal for a navigation satellite (see Cosmos 1295).

COSMOS 1305 1981-88A, 12818

Launched: 0841, 11 Sep 1981 from Plesetsk by A-2-e.
Spacecraft data: Cylindrical body, housing instrumentation and the payload and surmounted by a conical motor section. Power is provided by a "windmill" of six solar panels. Length is about 4 m, diameter 1.6 m and the mass around 2000 kg.
Mission: Replacement or backup for Molniya-3 (12), 1979-48A. The flight was a failure.
Orbit: 625 x 13864 km, 263.73 min, 62.83 degrees. Premature shut-down of the "e" stage resulted in an unsuitably low orbit for the vehicle to perform its communications functions.



The latest FLTSATCOM launch, 1981-73A, completes the five satellite system started in 1978. Intended for use by US military forces, the satellites have filled a gap in Department of Defense communications which was previously covered by the use of channels leased from the civilian operators of the MARISAT system. Built by TRW's Defense and Space System Croup, each satellite provides 23 radio channels from geostationary locations around the equator at 100 degrees west, 71.5 degrees east, 23 degrees west, 172 degrees east, and the latest at 73 degrees east.

ASTRONOMICAL NOTEBOOK

By J. S. Griffith*

QUASARS

Quasars behind galaxies

Now that two quasars have been detected as having images that are split and strongly intensified by the gravitational lens action of intervening objects, studies are being made of other effects of intervening galaxies on quasar images. Brightness amplification by undetected gravitational lenses could be responsible in part for the apparent evolution of quasars, with lensed quasars appearing much more luminous than the most luminous unlensed quasar. The presence of narrow absorption lines resembling the interstellar lines of our Galaxy in the spectra of quasars at specific redshifts differing from those of the quasar itself is explained by absorption in the extended halos of intervening galaxies.

The quasars Q0957+561 [1, 1a] and PG 1115+08 [2] are known to have images which are split and strongly intensified by the gravitational lens action of intervening galaxies. If the luminosity of other quasars has been greatly overestimated as a result of undetected gravitational lensing, then at least some of the infered quasar evolution may not be real. This possibility is investigated in [3], where it is pointed out that the apparently most luminous quasars will be heavily contaminated by lensed objects and hence their evolution cannot be interpreted literally.

In the spectrum of the quasar PKS 2020-370 ($z = 1.05$) Ca II absorption lines are found both at near zero redshift and at $z = 0.029$. The latter value is closely similar to the redshifts of two galaxies in the nearby group of such superimposition. The authors of [4] obtained spectra of the quasar and two nearby galaxies using the University College London Image Photon Counting System on the Boller and Chivens spectrograph of the European Southern Observatory 3.6m telescope.

* *Lakehead University, Thunder Bay, Ontario, Canada.*

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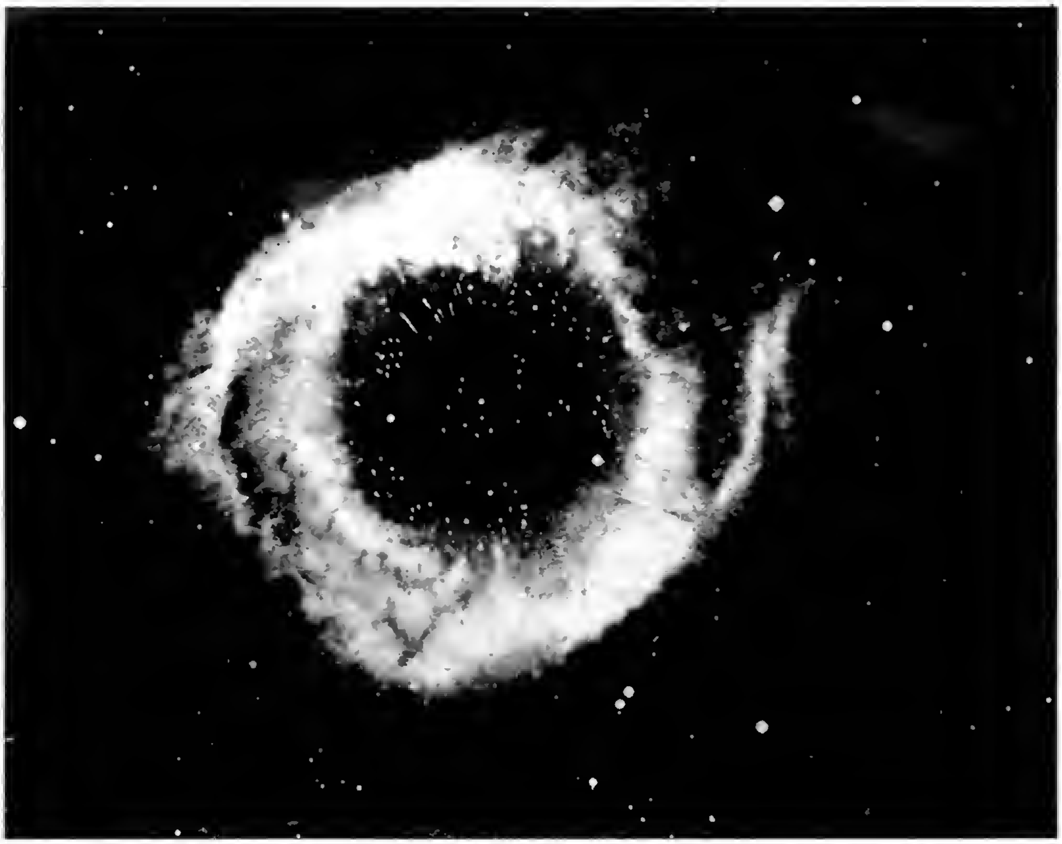
Observation of a gravitational lens?

The double quasar Q0957+561 A, B is seen to lie behind a rich cluster of galaxies. From model prediction it is shown that the cluster and the brightest galaxy together, acting as as gravitational lens on the light from a single, more distant quasar, can easily produce the present observations.

Using the 200 inch (5 m) Hale telescope, the authors of [1] took a series of deep red pictures of the QSO field. After additional observations, the case of a gravitational lens consisting of extended mass distributions through which light is passing was found to fit the situation. The details of the imaging are unfortunately unclear because of such uncertainties in physical parameters as the velocity dispersions in the galaxy



The Helix nebula (NGC 7293)

Anglo-Australian Observatory

The Abell 1060 cluster of galaxies
Anglo-Australian Observatory

and cluster, and the location of the effective cluster centre.

The authors comment on the complexity of this first case of gravitational imaging, stating that massive galaxies are more often found in clusters and groups. Additional cases may be found by examining high-redshift QSOs with moderate redshift absorption systems, such as those listed in [2].

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STARS

Collisions of asteroids on neutron stars

The direct collision of asteroid-size bodies with a neutron star is found to give gamma-ray bursts.

Previous authors [1,2] have studied the effect of a comet colliding with a neutron star in an attempt to explain the observed cosmic gamma-ray bursts. In 1979 a burst of gamma-ray radiation was observed in the direction of the Large Magellanic Cloud supernova remnant N49 [3], giving renewed speculation that neutron stars are the source of cosmic gamma-ray bursts. In [4] the effects of a collision of an asteroid or comet core with a neutron star are investigated.

As an asteroid approaches a rotating magnetic neutron star in direct collision, it is thoroughly tidally disrupted. Most of the matter is used up in the main collision with remnant debris guided down the magnetic field lines and raining onto the magnetic poles for a period of minutes following the main event. Observed periodic X-ray pulses occur as the hot spots at the poles come into view. Matter piling up at the poles on the hard surface is optically thick with a thinner ring. Gamma rays are produced. Eventually a gamma burst will be verified as coming from a known radio pulsar, and the period of the bursts should match that of the radio pulses.

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Supernova statistics

The interaction between supernova ejecta and the various environments within which the explosive event may occur is discussed. Only a small fraction of supernova events will give rise to observable remnants. The dominant feature is the density of the surrounding interstellar medium, with high density leading to an observable remnant.

In [1] the evolution of supernova shells into expanding, hot, low-density cavities is studied. Many stars (from binary systems) are given large velocities by the slingshot effect and can overtake the supershell. The authors estimate that from 10 to 35% of supernovae produce observable supernova remnants. Many supernovae do not occur in environments conducive to forming detectable supernovae remnants.

[1] Kafatos, M., Solia, S., Bruhweiler, F. C., and Gull, T. R., 'The evolution of supernova remnants in different galactic environments and its effects on supernova statistics', *Astrophys. Jour.* **242**, 294-305 (1980).

Magnetic Cepheids

An instrument has been constructed to measure the circular polarisation in 230 spectral lines simultaneously. This instrument was used to observe various Cepheids, and it appears that Cepheids as a class have magnetic fields of a few tens of gauss.

In recent studies of the discrepancy between the pulsational

The peculiar radio galaxy Centaurus A
Anglo-Australian Observatory

and evolutionary theoretical masses of classical Cepheids, it has been shown that a reconciliation may be made if a magnetic field is present, modifying the pulsations [1]. The authors of [2] used a modification of a radial velocity spectrometer to measure the circular polarisation in 230 spectral lines simultaneously. Using this instrumentation in conjunction with the Dominion Astrophysical Observatory's 48-inch coudé, observations were made of various Cepheids. The observed fields were consistent with the kilogram fields (in a tangled geometry) assumed in [1].

This discovery of magnetic fields in Cepheids (and in Supergiants) not only reconciles pulsational and evolutionary masses, but may also provide a fourth parameter in the period-colour-luminosity relationship and may lead to modifications in the distance scale. Now that we know Cepheids and Supergiants are magnetic, it is reasonable to wonder whether other pulsating variables and giants are also magnetic. It has been found that a magnetic field could provide the necessary mixing to reduce the high c^{12}/c^{13} ratio predicted by stellar evolution models to the lower observed values [3].

[1] Stothers, R., *Astrophys. Jour.* **178**, 441 (1979).
[2] Borra, E. F., Fletcher, J. M. and Poeckert, R., submitted to *Astrophys. Jour.* (1980).
[3] Hubbard, E. N., and Dearborn, D. S. P., *Astrophys. Jour.* **239**, 248 (1980).

Wolf-Rayet stars

A survey of the masses, mass ratios and orbital parameters of Wolf-Rayet binaries is presented. It appears that orbital angular momentum losses are greater than expected, and that mass transfer has not played a dominant role in the evolutionary process.

It is generally accepted that Wolf-Rayet stars (WR) result from the peeling off of the outer hydrogen-rich layers of an O-type star, revealing material processed by nuclear reactions. This mass loss may either be carried by strong stellar winds or by Roche lobe overflow in a binary.

In [1] it is pointed out that WR masses span a greater range than usually accepted, and that the average mass is twice as large as the traditional value, being 20 solar masses. In binaries, WR stars have lost at least 40% of their original mass.

Mass loss from a binary system also involves loss of angular momentum, affecting the orbital parameters. Mass transfer between components would tend to circularise orbits, a feature that is not observed.

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GALAXIES

A 'young' galaxy?

IZw 18 is a blue compact galaxy, with about 6 hydrogen clouds, each of around ten million solar masses. The present burst of star formation is probably not older than 2×10^7 years, and may be the first in the history of this galaxy.

IZw 18 = Markarian 116 is the galaxy with the smallest known abundance of heavy elements; there is very little oxygen, neon or nitrogen. The abundance of helium is one of the lowest known. This indicates that it is made of relatively unprocessed material (heavier elements being built up from hydrogen by nuclear fusion within stars) and thus that the average rate of star formation in it since the beginning of the Universe is very low. In [1] it is pointed out that the present burst of star formation is the first, and that consequently IZw 18 consists of almost primordial material. The authors of [1] used the Westerbork (Netherlands) Synthesis Radio telescope to observe the galaxy at 21 cm. The neutral hydrogen structure of IZw 18 is very complex with about six large components. It appears that IZw 18 is a galaxy in the process of formation by the merging of two or more primordial clouds. Interaction between these clouds has led to a burst of star formation which started less than a few 10^7 years ago.

[1] Lequeax, J. and Viallefoud, F., 'H 1 observations and star formation in the blue compact galaxy IZw 18', *Astron. & Astrophys.* **91**, 269-275 (1980).

Galactic light as cosmological probe

The energy density of the background intergalactic light is dependent on three parameters. These are the epoch at which galaxies formed, their luminosity evolution and the form of the cosmology. Theoretical distributions of extragalactic background light (EBL) are calculated using a range of universe models and experiments described that will enable us to gain information on the three parameters. Present data indicates either that galactic luminosity evolution is not very large or that Hubble's constant is closer to 100 kmsec⁻¹MPC⁻¹ than to 50 km sec⁻¹MPC⁻¹on possibly both.

In Ref [1] it is pointed out that suggestions have been made that quasars are young galaxies in a superluminous phase. A test of superluminosity is to estimate the amount of radiation which galaxies may be expected to produce over their lifetimes and to compare this with observations of the EBL. Of course, the predicted EBL is dependent on how the universe evolves with time. The EBL is a general cosmological probe, sensitive to the evolution of sources and to the dynamical evolution of the universe.

It is found that the epoch of galaxy formation and their subsequent luminosity evolution have a large effect on the energy density of the EBL. Lemâitre cosmological models can be ruled out from present observations. These observations also rule out the suggestion that young galaxies are much more luminous than older ones.

Further observations that are suggested include observations of the EBL at infrared or microwave wavelengths.

[1] Stabell, R. and Wesson, P. S., 'Background light from galaxies as a cosmological probe', *Astrophys. Jour.* **242**, 443-447 (1980).

SATURN'S "SPOKES"

By R. Beck and R. Koppmann
Astronomical Institute, Bonn, Germany

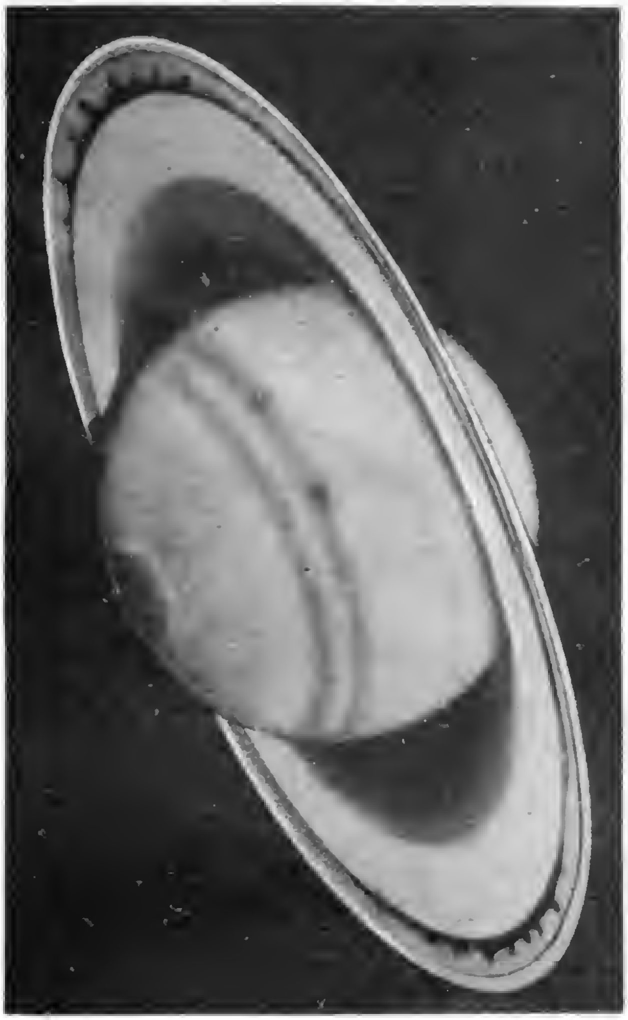
Following Voyager 1's encounter with Saturn in 1980, some of the photographs of the rings showed a surprising feature: finger-like bridges crossing the B-ring which seemed to violate Kepler's laws of planetary motion. They were named "spokes" and are generally believed to have been discovered by the Voyager cameras ("... features of the rings of Saturn that have never been seen before appear in this photograph by Voyager 1 ... "[1]). J. Meadowes and N. Henbest reported in *New Scientist* [2] that the spokes were not discovered by Voyager 1 but that E. M. Antoniadi "was convinced he had observed such markings" in 1896.

An even older visual observation of the spokes can be found in the German journal for popular astronomy *Sirius* in 1888 [3]. In this paper, observations of Saturn made by Paul Stroobandt at the 14 inch refractor of the Bruxelles Observatory were reported with the following description of the rings:

"Man bemerkt auch einige Zahnungen, die von der Cassinischen Trennungslinie ausgehen und auf der westlichen Seite in den äußeren Ring eingreifen. Diese Zahnungen scheinen sich, gleich feinen Strichen, tiefer in den Ring hinein fortzusetzen."

["One also notes some teeth-like features which start at the Cassini division and interfere with the outer ring on the western side. These 'teeth', like narrow lines, seem to continue deeper into the ring."]

A third source concerning visual observations of the spokes is contained in a colour drawing made by Lucien Rudaux at the Observatory of Donville (France) and is published in the book *Le Ciel* [4]. These reports show that telescopic observations and drawings of Saturn were (and still are) very effective in showing details never seen on photographs, but they were forgotten for a very long time.



This 1923 representation of Saturn (the original is in colour) clearly shows spoke-like features in the rings.

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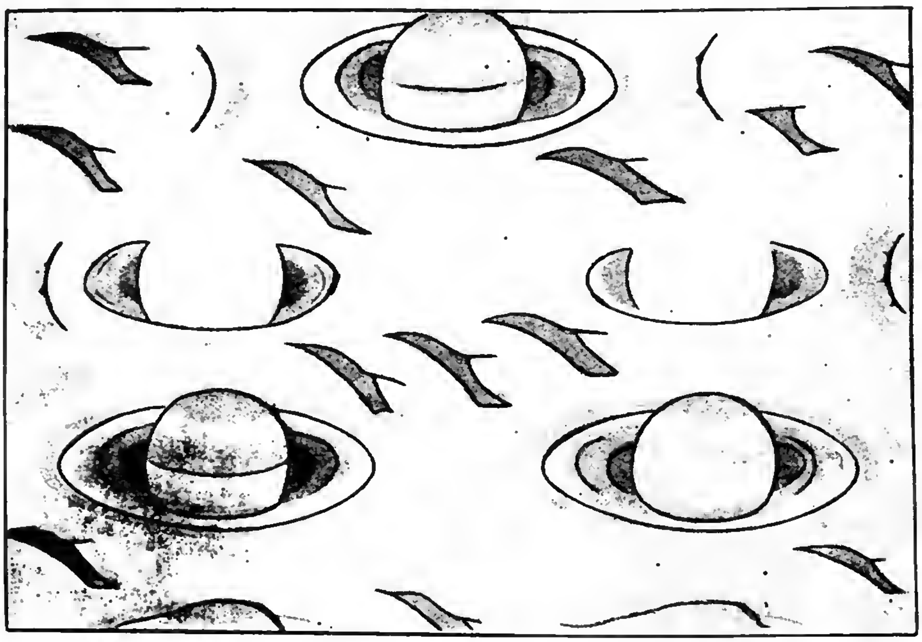
3. P. Stroobandt, "Beobachtungen des Saturn und seiner Ringe auf der Sternwarte zu Brüssel," *Sirius* 21, 4, p. 73, 1888.
4. Alphonse Berget, *Le Ciel*, Larousse, Paris 1923.



Drawings made by Paul Stroobandt of Saturn and its rings as observed through a 14 inch refractor [3].

PUBLICITY ROLLS ON

It is increasingly difficult to keep track of the many references to the Society which appear in the news media and at various events throughout the world so, to a large extent, the references which find their way to us are probably fortuitous. However, they are of considerable interest insofar as they show the many ways in which publicity may be sought, and found!

Magazines and Periodicals

The first event was a visit from a photographer for *Interdisciplinary Science Reviews* anxious to reproduce one page from a very early issue of *JBIS*.

The post brought a cutting from the September issue of *Space Mirror* – a supplement produced by the *Daily Mirror* Newspaper which mentioned the Society in connection with Daedalus. On the otherhand, *Ariel* for 27th May last made no reference to the Society at all but was more concerned with promoting the activities of Mat Irvine, accompanied by a photograph of him showing both an attractive companion and his attractive T-shirt, prominently disclosing the name of the Society.

Our new magazine, *Space Education* received publicity in the *Association for Astronomy Education News* while Robin Kerrod, in literature advertising his fine space charts, also indicated that he is a Fellow of the Society. Farther afield, two issues of JPL's *Universe* commented on the Society's participation in the Globe-trotting Marathon to see the last lunar eclipse; *International Aerospace Abstracts* continued to feature material published by the Society and a new venture, The Space Press of New York, not only introduced themselves as publishing a monthly devoted to space activities but requested information to plan a profile of the BIS.

Books

With publishers feeling the pinch and few titles appearing the Society has, nonetheless, done very well.

Guy Alimo's *The Hunting of Salyut 7* mentions the BIS on page 459, Robert Power's *The Coattails of God* mentions both the Society and Daedalus many times while many drawings and illustrations from the Society's records appear in a book on Science-Fiction prepared by Kazuho Hamada and published in Japan.

Additionally of course, plans are still going ahead for the American Astronautical Society to publish the papers presented at the 17th European Space Symposium, of which our Society was a co-sponsor.

Displays and Exhibitions

Foremost among the exhibitions was "Planetfest '81" arranged by the Planetary Society, a young organisation founded by Carl Sagan and growing rapidly. This was a magnificent exhibition at which material from our own Society was on display, along with application forms, etc.

At the other end of the scale, so to speak, were batches of literature* sent to support local groups, e.g. the South Lincolnshire Astronomical and Geophysical Society in October, the London Computer Show in mid-September and a meeting of Norton Hall Scientific Society in October

Mat Irvine, BBC modelmaker and BIS member, made an appearance in the BBC Staff Journal *Ariel*. Not much in the way of publicity for the Society you might say, but notice the T-shirt Mat is wearing!

Mrs. Rozelaar thanked us for the package of space material sent for teaching purposes at her school in Solihull, as did other teachers for similar support.

Distance proved to be no object. Professor Holbrow was given permission to copy various articles for his class at Colgate University in New York, Mr. Parish was sent a batch of

HISTORY OF THE SOCIETY

The Council is examining the possibility of publishing a History of the Society to mark its 50th Anniversary. They would like this to be as well illustrated as possible and would ask any members who might have in their possession illustrations relating to activities of the Society if they would like to present or lend them for possible inclusion in the volume. Illustrations are sought relating to Visits, Meetings, early Congresses of the IAF, and Presentations.

The types of illustrations needed are as follows:

(a) Pictures of any Society functions e.g. Honours, awards, meetings, etc.
(b) Early Congresses of the IAF which feature Society participants.
(c) Projects in which the Society has been involved.
(d) Individuals who have been associated with any Society activity or project are invited to submit a personal photograph and a few lines outlining their association.

Material of a pre-war or early post-war character would be of particular interest. Details should be sent to the Executive Secretary with photocopies of the appropriate items if practicable.

**Members wishing to distribute batches of Society magazines to interested parties during a film show, meeting or similar event may apply to the Society. Please include a remittance of £2 to defray postage.*

Major General Heinz S. Fuchs, BIS Fellow and Professor of Aerospace Medicine at Justus Lievig University, has been awarded the "Hubertus Strughold Award 1981" of the Space Medicine Branch, Aerospace Medical Association, Washington, D.C.

The picture shows General Fuchs (right) receiving the award from Hubertus Strughold himself.

material for a Space Research Exhibition in New Zealand and Geoff Davies was sent a quantity for a proposed space course being arranged by the Astronautical Society of Western Australia.

Not everyone could be accommodated so easily. Ms. Stafford, for example, wrote at the end of May for material for her Astronomy Club exhibition in mid-July but, since this had to reach Hawaii and air mail was out of the question, we had to decline as time did not permit.

Radio and TV

Carl Sagan's *Cosmos* series, which appeared on BBC TV recently, included some very handsome references to the Society and to the Daedalus Project, with Andy Wilson adding to the flow with a Capital Radio broadcast on the Saturn Fly-by which was recorded on 26 August at the US Embassy during a reception put on there by Motorola.

Out of Roses

Unfortunately, it wasn't roses all the way for everyone. Andrew Cooper, for example, obtained data from the Society to refute arguments that he had heard at a lecture on "Astral Projection". Unfortunately, he was spotted by the Lecturer at the repeat performance, who promptly sent for the Police and had him ordered out of the hall "using language," Andrew says, "which I wouldn't care to commit to paper!"

VISITORS

Hurrying back from his Solar Eclipse spree early in August, yet with a stop-off at HQ en route to JPL for the fly-by of Voyager was Bob Frampton, President of the BIS Southern California branch.

Bob's hurry was explained by the fact that he is Guidance and Control Analyst at JPL with responsibility for work on the Voyager manoeuvre design for a radio science experiment studying Saturn's atmosphere.

Close behind came Dr. (Bill) and Karen McLaughlin – also on their way back from the eclipse and returning to the US via Oxford, of all places.

Bill is currently working on the Infra-red Astronomical Satellite (IRAS) at JPL jointly with SRC and NIVR (Dutch). Launch is scheduled for August 1982. At the time of his visit the satellite was in the Netherlands for integration and tests, after which it was due to be shipped back to the USA for more testing.

Karen is also at JPL, as Systems Analyst, working on Data base designs for Galileo and Voyager.

Counsellor Justin Bloom of the US Embassy in London.

We were very happy to welcome in late October Justin L. Bloom, Counsellor for Scientific and Technical Affairs at the US Embassy in London, occupying the same position which he used to hold at the US Embassy in Tokyo where he then represented NASA interests, among others.

Counsellor Bloom has a space background. For example, he worked for the Martin Marietta Corporation on auxiliary nuclear power supplies for spacecraft (SNAP) – basic work which made the success of Voyager possible.

We were particularly interested to have some updated information from him about space activities in Japan. He was telling us, for example, about the Space Shuttle Club of Japan, strictly a private organisation of ordinary people who want to travel on the Shuttle as passengers. It publishes its own magazine and includes a recently-retired senior Japanese Space Official as President. Incidentally, NASA actually conducted a study for a configuration of the Shuttle to carry passengers. By all accounts it could take up to 70 people, in the manner of a double-decker bus, though the cost per passenger would, of course, be phenomenal!

The Japanese are studying the possibility of orbiting their own manned space vehicle, using an N-2 vehicle. Basically this is a Delta launcher built under license, and with a cryogenic second stage it would be able to place 550 kg in geosynchronous orbit. With further modifications it could reach even 1000 kg – in the Ariane class.

OBITUARIES

CHARLES SHELDON

Followers of the Soviet space programme were saddened to learn of the death of Charles Sheldon, one of the Society's most distinguished Fellows, on 11 September 1981.

At the time of his death he was involved in coordinating the next in the series of reports on the Soviet space programme which have become standard works of reference throughout the western world.

The February *Journal*, devoted to papers on Soviet-related topics, is dedicated to the memory of Charles, with an appreciation of the man and his work by Geoffrey Perry.

P. J. MADILL

At the same time, we are also very sorry to announce the death of Peter James Madill, one of our newest Members, at the age of 24.

Peter, who was an Ambulance-Paramedic, sacrificed his own life while responding to a downed aircraft call. His mother, breaking the news to us, said that Peter, whose interest in space began at the age of 10, had been most excited about becoming a Member of the Society.

Sadly, he did not live to see his Certificate of Society Membership, which has been framed and now hangs proudly with his other citations.

SOCIETY MEETINGS

"FIRST NIGHT"

Introducing new members to the Society *via* the "First Night" informal evening is always a pleasant task. It gives everyone the opportunity to learn more about the Society, as well as getting to meet one another and some of our Council and Committee Members.

The 1981 event was held on 7th October with a magnificent buffet organised by Miss Jones, Mrs. Arthur and Mrs. Groves. Add to this a visit by an honoured guest all the way from Hawaii and it is no wonder that a good time was had by all.

Martin Fry – the organiser of our *Space '82* weekend conference next November – took the Chair to welcome members on their first visit to the building. Some had travelled from as far afield as Southampton and Leicester but the record must have been held by a visitor from Australia. There was a suspicion, however, that he hadn't travelled thousands of miles just for the meeting!

Len Carter kicked off the evening's schedule with a supersonic 10-minute description of the Society and its plans for the future. The next time we hold a "First Night" we may well have a souvenir booklet with this type of information – so our Executive Secretary will be able to sit back with his feet up!

Perhaps the most astounding fact that Len mentioned was that the Society publishes a magazine about once every 11 working days. This is an incredible rate when a single issue carries around 50,000 words. Into this gaping maw we have to cram, ceaselessly, innumerable articles, news items, book reviews, reports of meetings or other Society activities, send out hundreds of letters, correct and re-check proofs, find and locate photographs, obtain scaled-down drawings, select suitable items of corresponoence, merge in details of forthcoming meetings, liaise with various committees that are undertaking different projects which they may want publicised by specific dates, try not to forget the requirements of the occasional advertiser and, generally, to soothe ruffled feathers all round.

There's always the occasional letter from a Member pointing out that his magazine was incomplete or did not arrive, or that some change of address had or had not been recorded.

We always have the added problem that we are not dealing with one magazine at a time. Normally, we are working simultaneously on at least six magazines, all in different stages of progress.

A SATISFIED CUSTOMER

Sir, I am writing to let you know how much I enjoyed the "First Night" meeting, my first visit to the Society headquarters.

I was impressed with the premises, found the talks and film very interesting, and the hospitality most pleasant – very many thanks to all concerned.

JOHN MACMASTER

Professor Groves was limited even further – as Chairman of the Education Committee he had to give a rundown on their work in 5 minutes. Martin Fry briefly outlined the plans for *Space '82* with the advice that everyone should keep their eyes on *Spaceflight* for future announcements.

Our guest speaker was more fortunate with his time. Deane Davis was intimately involved (along with Kraft Ehricke, a BIS Fellow) with the Centaur high-energy upper stage programme from its inception in the late 1950's, right through until his retirement five years ago soon after Voyager was launched towards Jupiter by a Titan-Centaur. His rocket career stretches back to the days of the V-2 firings at White Sands. He was blissfully ignorant of the BIS until a friend sent him a copy of our Daedalus Report, and found that he had "read nothing like it in 20 years." Being in the aerospace industry he was more concerned with the nitty-gritty of actually getting the hardware into Space but now he has come to believe that our type of work is vital. Projects such as Daedalus lay the groundwork for future generations of engineers to build upon.

Deane had one very illuminating anecdote: it can now go on record that a secretary's girdle made a major contribution to the American space programme. Designing the bulkhead between the liquid oxygen and hydrogen tanks in the Centaur proved to be a knotty problem but eventually they decided on a version which required the bulkhead to move as the propellants were depleted. Part of the design included fibreglass but they found that it did not slide easily at such low temperatures. The solution came one day when an engineer was watching a secretary and wondered whether she was wearing a girdle. He disappeared for a while and returned triumphantly with the undergarment. Tests showed the material to keep its

Deane Davis kindly gave us this photograph of an occasion back in 1961 at Convair's Atlas plant in San Diego. It shows Deane (centre) presenting Wernher von Braun with a gesture which might be easily misinterpreted! Second from the right is Karel (Charlie) Bossart, mastermind of the Atlas missile which is still in use today as a space launcher.

Professor Groves, Chairman of our Education Committee, describes the Society's educational work to new members. Behind him, Martin Fry (left) and Len Carter both give the distinct impression of being asleep! No doubt they were contemplating the approaching delights of the buffet.

Below right: a guided tour of the Library.

stretching qualities at cryogenic temperatures – the problem was solved! Not a tale to be found in the official reports.

Deane commented that "we will be firing Atlases right into the 1990's" even though the first launch was as far back as 1957. Those early days weren't always easy: "we were up to our arses in alligators [at the Cape]". The Centaur was designed as a *space* vehicle and a large proportion of the cost went on testing it on the ground under simulated space conditions.

Following a break for the buffet everyone had a chance to see the library, still expanding apace. That very afternoon, Pat Ladd had delivered two brand new display cabinets just in time to have them filled for the evening meeting.-Now our Saturn 5 and Shuttle models can be admired by all, instead of them languishing hidden away for protection.

One of the cabinets, a tall affair with glass on three sides, had provided a few moments of anguish during its delivery. It was carefully unloaded and placed upright on the pavement. Two of the three helpers then, magically, disappeared. The Secretary, finding himself unable to move the cabinet any further, let go to look round for them. That was the exact moment when a great gush of wind caught the cabinet and blew it over, to crash majestically into the road.

The Secretary, white with fear, turned to look at the cabinet, expecting slivers of glass everywhere. To his intense relief, as he gingerly re-stood it once more, not a single pane had been smashed.

This was altogether too good to be true: he stared at it in amazement. At that point, Pat re-emerged and was told the amazing story of how the thing had gone over with a crash without any smashing of the glass.

"It wouldn't", replied Pat, "You specifically asked that it be made of unbreakable glass!"

Len got out of it beautifully. "I was only testing it", he said!

The evening's *finale* was a half-hour NASA film covering the first Shuttle orbital mission last April. This was the first time that most of us had seen it and it was, to say the least, breathtaking. The launch sequence was superbly presented and revived memories of days gone by when Saturn launches to the Moon thrilled us with their power and spectacle.

Although the evening began at 6.30 p.m. it was 10 o'clock before the meeting broke up with the unanimous opinion that it had been highly enjoyable. It was even worth a trip from Australia!

Deane Davis describes the problems of designing the Centaur rocket stage.

THE ARIEL 5 & 6 EXPERIENCE

Britain does not make enough of the success of her modest satellite programme. Following a previous lecture on Ariel 4, Dr. Martin Ricketts told us on the 2 September 1981 about the "Ariel 5 and 6 Experience." Martin had been involved at the University of Leicester with the production and development of Ariel 5's software from about two years before its launch. After that he worked on the hardware for Ariel 6, and since then on ESA's Exosat.

Refreshingly, Martin gave us a blow-by-blow account of the practical difficulties (seen from an experimenter's point of view) of developing a scientific satellite, illustrated with his own slides. His chronology of events showed how the overriding need for economy forced many changes in Ariel 5's design. For example, Ariel 5 was originally planned to be controlled by an on-board computer, but the computer's slow development made the substitution of a simpler memory core necessary. As a result, the time and space resolution and amount of data that could be collected were all reduced. He gave a graphic account of commuting regularly between Leicester and Portsmouth with a PDP-8 testing computer in the back of the car. Throughout the development period the experimenters had to cope with steadily degrading sensors. They suspected that the degradation was due to the high humidity near the sea.

There were compensations. Martin's slides showed how the experimenters really spent their free time in Kenya in the month before the launch from the San Marco platform. We saw three or four members of the team in a dugout canoe with a lateen sail on a joy-ride to the nearby village of Lamu. Another slide showed that one onlooker was more intent on his fishing than on the launch of Ariel 5.

After showing us some of the results from Ariel 5, Martin turned to Ariel 6. There was insufficient time to go into detail with Ariel 6, but we learnt that some of the lessons from Ariel 5 had gone home. The sensor degradation on Ariel 5 was avoided by providing sensor covers with silica gel packets to keep out the moisture, and there were more elaborate calibration arrangements. On the other hand, there was a long period during the development of Ariel 6 when the promised delivery dates of some experiments slipped by one month for every passing month. Finally, everything came together, and the satellite was assembled, tested and shipped to USA. Two years after its launch from Wallops Island, Ariel 6 is still returning data. Although the satellite can work well beyond its design lifetime, the need for stringent economy has meant that the reduced ground support limits observation to a rate of one hour per day. What an economy!

TJC

50th Year Activities

NEW SHUTTLE CONFERENCE

The Society is pleased to announce that, in co-operation with the American Astronautical Society, the National Space Club, the Deutsche Gesellschaft fur Luft und Raumfahrt and the Japanese Society for Aeronautical and Space Sciences, they have agreed to co-sponsor the bi-annual Space Systems Conference which will be arranged and organised by the American Institute of Aeronautics and Astronautics on October 18th-20th 1982 in Washington D.C. U.S.A.

The theme of the Conference will be *The Space Transportation System – a review of its present capability and evolution.* Subjects to be dealt with will include:

(a) The Space Shuttle Orbiter
(b) Orbital Transfer Vehicles
(c) Reusable vs Expendable Launch Vehicles
(d) Man's Role in Ground and Flight Operations
(e) User Needs for a Space Truck
(f) The Orbital Facility Applications

The date of this meeting will coincide not only with the Society's 50th year celebrations, but also at a particularly significant time for the Space Shuttle itself which, having successfully completed its first two flights, will have performed additional missions by October next. Future requirements for a Space Transportation System will, by then, have become more defined.

BIS Authors intending to present papers to the AIAA meeting should, in the first instance, contact the Society's Executive Secretary, 27/29 South Lambeth Road, London, SW8 1SZ, from whom fuller details will be available in due course.

The same applies to members of the Society who plan to attend the Conference.

THE YEAR IN RETROSPECT

The space year of 1981 will be remembered as one of achievement and spectacle. Voyager 2 sent back stunning pictures of the Saturn system in August, and astronauts Young and Crippen started off the Shuttle flight programme with a magnificent success in April. On the Soviet side, Salyut 6 began its fifth year in space on 29 September, although it appears to have seen the last of its visitors. 1982 should bring Salyut 7.

Philip Clark and Anthony Kenden took on the task of reviewing the past year for a packed audience in the "Recent Advances In Spaceflight" meeting on 14 October. Tony concentrated on the American military side – noting that out of 18 US orbital attempts in the year following October 1980, nine were civilian and nine military. The usual military requirements of navigation, reconnaissance, early warning and communications were all served by launches, and it is noteworthy that none were new programmes but were rather concerned with systems already in operation.

CORRESPONDENCE

Tunnelling our Moon

Sir, Dr. Sheppard's article (*Spaceflight*, November 1981, pp. 291-294) gave a very illuminating description of the possibilities of colonising the Moon. Significantly, the methods proposed are based on current technology and it is shown that it is possible to "provide an alternative home for mankind that is as large, varied and beautiful as our own Earth".

There is, however, a sting in the tail.

Even though heat and power would come from the Moon's own internal heat and from solar energy, we find that the tunnels built to accomodate mankind are also "the best available site for disposing of nuclear wastes from Earth".

Surely the burial of nuclear waste in stable rock strata is not yet a proven method of disposal. And why consider the Moon as a suitable site in parallel with providing human habitation, especially as it is only a "hopeful" assumption that the Moon has somewhere on its surface a mass of unfractured rock which has a leakage of only practically zero?

Future colonisation should not automatically include a nuclear waste disposal scheme especially where that waste is not produced by the colonists.

D. SIMS
Herts

It balances out ...

Sir, The review of the "Daedalus In Retrospect" symposium (Held on 6 May 1981 and reviewed in *Spaceflight*, 23, 8, p. 277 - Ed.) was less than fair to me in one place and more than fair in another!

I actually presented four papers, not three, at the symposium. The missing one was entitled "Daedalus Probe Requirements and Deployment Patterns as a Function of Reliability."

On the other hand, I was credited with "... introducing the Warden concept." I wish that were so. The true inventor of the concept, like so much else, was Alan Bond.

One all, perhaps?

TIM GRANT
Herts

Global Space Agency – 1

Sir, Ian Crawford's article in *Spaceflight* (November 1981) on the possibility of forming a global space agency should certainly not be dismissed out of hand.

Existing space agencies are not well funded. They experience the well-worn argument that world poverty should be eliminated as an alternative to space programmes. There is a very real need to deal with world poverty and equally great a need to be about our business in space. Both areas can be dealt with simultaneously; one activity will then supplement the other.

The Brandt Report may at first sight seem an unlikely launch pad for a global space effort. Yet the Mexico summit in October 1981 left the delegates willing to defeat world poverty but unable to find a means of bringing it about.

Ian Crawford mentioned that the organisation of today's world is increasingly dependent on space technology. This technology is already at the disposal of those who intend to develop the remainder of Earth's limited resources. Therefore, to bring about the aims of the Brandt Report, there will need to be a mutual dependence between Earth and space projects.

Dr. D. J. Sheppard, also in the November issue, writes of exciting projects for tunnelling our Moon. Where better to rehearse for such a venture than in the arid regions of our own planet? Practice runs can at the same time bring real wealth to the poor of such regions.

Ian Crawford hit the nub of the problem in how best to get round the vexing problem of military confrontation in space between the super-powers. An emphasis on trade-like competition instead of war-like rivalry is indeed a good answer. Given a good international platform to pose the question, suicidal war or the possession of enormous wealth from space commerce, it is likely that all stable governments will opt for the greater good.

Of interest from out of the Mexico summit is Lord Carrington's reported remarks that Britain also supported the proposal for establishing a separate "energy affiliate" as a means of getting more OPEC funds for the exploration and development of energy resources. He said that food, trade and energy were the three most important aspects for such aims. Let us here mention the ultimate foundation element of both Earth and space projects – water.

The science of weather control and the engineering skills of bringing water to places presently without are areas for preliminary study and application on Earth before they can be practised on other planets.

C. VILES
Surrey

Global Space Agency – 2

Sir, I imagine that few BIS members will disagree with Ian Crawford's remarks on "the futility of national differences."

Many years ago now Churchill spoke of "the broad uplands". They seem a long way off at the moment, but I believe they are nearer than we think. But until we are able to work as an entity we are neither ready nor fit to explore space widely. It requires a very open and lively attitude to life and its yet-unsolved mysteries. Preconceived notions, whether religious or atheistic, will get us nowhere. A paradoxical mixture of humility and adventure will be needed.

Our tremendous and rapid advances have only taken place because we believed they could. The same applies to Ian Crawford's vision of a Global Space Agency. It will happen if enough of us believe that it can.

JOHN ALLISON
West Midlands

Shades of a distant past

Sir, When I read in the October 1981 issue of *Spaceflight* that Penny Wright had acted as "Lady Chairman" at one of the Meetings of the Society, it took me back in memory nearly forty-seven years, when an Ordinary Meeting of The British Interplanetary Society was held at The Hamilton Cafe, 56 Whitechapel, Liverpool.

The date was 28 December 1934. A report on the meeting states that it was "enlivened" by the Chairmanship of Miss Eileen Hastie.

L. J. JOHNSON
Liverpool

From the AIAA:

Sir, Thank you on behalf of AIAA for your cover story on the 50th Anniversary of AIAA in the August/September 1981 issue of *Spaceflight*.

The Editor is always interested in receiving items of correspondence, notes, comments, or reviews for possible publication. Items submitted must be kept brief, owing to the limitations of space in our magazine. The Editor reserves the right to shorten or otherwise adapt material to fit, for this reason.

We treasure the long, cordial and stimulating relationship between the American Rocket Society, the AIAA and the BIS and look forward to many years of continued cooperation.

It seems to me that there is much to be done in developing viable cooperative space programmes in the next 20 years. It will be quite a challenge to AIAA and to BIS to articulate those programmes and gain support for them from our respective governments.

Upward and onward!

JAMES J. HARFORD
Executive Secretary, AIAA

The Search For Intelligence–2

Sir, It is clear from Michael Taylor's letter (*Spaceflight*, 23, 7, 1981) that he continues to misconstrue my views and to emphasise minor parts of them:

(1) I did not just indicate language served a "labelling, indexing and mnemonic function" but I stressed, more importantly, its role in the evocation of imagery (perceptual versus communicative roles, precedence of imagery over language in creativity, equivalence of concepts and images, etc.) an issue to which Taylor makes no comment.

(2) The use of language in the triangle experiment does direct attention to given aspects (apex and opposite base) and to say this is possible "in principle" without language means just that: an individual can direct his attention to any given apex/base pair, in whatever order, each creating a different experience (analogous to the different experiences of a map and its inversion).

(3) In crediting to me the contradictory belief a concept is not a concept unless it is a word, Taylor fails to grasp the word/concept distinction I draw (why I stressed the classical physicist and the relativist as having different concepts despite similar vocabularies). Also, I did not imply the meaning of a word derives from its etymology but that its etymological root/s were defined ostensibly (thereby reflecting their perceptual basis).

(4) Because of the word/concept distinction it is obvious why "terms" like "justice", "truth", etc. are only words, not concepts. Furthermore, the linguistic analysis approach Taylor adopts, carried to its logical conclusion, would require each of us to define all the words we employ in a given discourse. I would no more attempt this than any other scientist: the words one employs acquire their specific meanings in terms of one's entire conceptual framework (witness the classical physicist and the relativist). In any case, I implied a deep relation between "concepts" and "perceptual images".

(5) Contrary to Taylor's belief that logic reflects "certain natural modes of thought" it only plays a relatively minor role in thought: logic is applied retrospectively (which is why the mathematician Henri Poincaré said, "It is by logic that we prove but by intuition that we discover."); it is a widely accepted convention; logic is purely analytic (not synthetic); and where logical conclusions fail to make reference to experience they are susceptible to the grossest distortion (witness hermits and various linguistic philosphers). The perceptual basis of logic can also be readily indicated. Asked, say, whether A is greater than C, given $A>B$, and $B>C$, we apply the image of size (e.g. length) to the individual items (A,B,C) thereby seeing that A must be greater than C (i.e. $A>C$).

E. J. COFFEY
London

Michael Taylor replies:

If the theory of language on which Coffey bases his thesis is inadequate then, clearly, any edifice constructed on such a foundation must itself be flawed. Consequently, I do not emphasise the unimportant. Neither is it a serious omission to make no mention of the role of language in the evocation of imagery, as this is only a semantical point away from its

Frederick Ordway mentioned in a letter ("Dornberger and Bonestell") published in the November 1981 *Spaceflight* that he owns 50 original Chesley Bonestell paintings. Since then he has been kind enough to send us a photograph - reproduced above - of a painting which he also owns, depicting the British rocket pioneer Sir William Congreve. The original, by James Lonsdale, is on display at the Alabama Space and Rocket Center in Huntsville.

mnemonic function. The equation of concepts with images is, moreover, a crude error, admirably dealt with by Flew in *Hume's philosophy of belief* (pages 23ff.), which implies a congenitally blind man could have no concepts.

The point of the triangle experiment is this: is it possible for (e.g.) a cat, without language, to have the same experiences as a human being who has? Mr. Coffey's response misses the point that we can have these experiences in the first place only because we understand something of the language of geometry.

Mr. Coffey's comments in paragraph 3 indicate a misreading of my earlier remarks. Furthermore, in his fourth paragraph Coffey is guilty of the "conventionalist sulk"; his theory presents a generalisation as a matter of universal but contingent fact (i.e., linguistic signs simply label pre-established concepts) together with some evidence which purports to demonstrate its validity, and he then refuses to accept as genuine any counter-examples offered (justice, truth) on the grounds that, as the original generalisation is true, what is offered cannot possibly be a genuine case of whatever it is would falsify it ("terms like justice are only words"). It is as if I were to say "All Englishmen have eggs for breakfast" and when someone pointed out that Mr. Smith, who was an Englishman, did not eat eggs I replied "Then Mr. Smith is not an Englishman, because all Englishmen eat eggs for breakfast". Coffey thus transforms his generalisation into a pretentious tautology, true by convention of the (mis)use of the words involved.

Mr. Coffey's statements about the status of logic deal superficially with a complex issue. I accept that the propositions of logic are true by convention (*vide* my article "Why?"), but I do not see how this entails that logic is not a natural mode of thought.

This correspondence is now closed – Ed.

SNIPPETS

What's in a name?

Sir, There has been a lot of talk about changing the name of The British Interplanetary Society. What a load of "hogwash" and an utter waste of time. I for one do not believe in change for change's sake. The BIS has established an excellent reputation around the world with space agencies, scholars and publishers alike. Why then change the name which may produce nothing but confusion.

RICK MULHEIRN
Merseyside

Society Motto

Sir, "WE BRIDGE THE VOID" takes us to Clarke Orbit, and a little beyond, but "ACROSS THE DEARTH?" sounds better, don't you think?

N. KELLY, BSc, AFBIS
Liverpool

Not *really! – Ed.*

If only ...

Sir, May I take this opportunity to thank you for all your hard work and the wealth of information that comes each month in the form of *Spaceflight*. I joined the Society when I was 16 and my only regret is that I missed out on 16 years' worth of issues.

Oh well!

M. A. COWELL
Surrey

BOOK REVIEWS

The History of Manned Spaceflight
David Baker, New Cavendish Books, 544pp, 1981, £19.50.

Anyone who has read Dr. Baker's books and articles (many of them in *Spaceflight*) will know the high standard of his work. This book is no exception. In "The Rocket" he traced the development of rockets from ancient times to the present in great detail. Now, in this companion volume, he traces the fascinating story of manned spaceflight up to early 1981.

We are taken through the trials and tribulations of the American programmes at length but, of course, the Soviet side cannot be treated in the same way. Beginning with the early theoreticians (the BIS is extensively mentioned) we travel through Mercury, Vostok, Gemini, Voskhod, Soyuz, Apollo, Skylab and Salyut, ending just short of the Shuttle. It is a well-covered subject but this is the first time it has all been put together under one cover in such detail. The result weighs about 10 lb – not something to be carried around to be read at odd moments!

This is a major addition to any space-buff's shelves and one which will remain valued for years. Dr. Baker is to be congratulated on his work.

Red Star in Orbit
J. E. Oberg, Harrap, 272 pp, 1981, £7.95.

James Oberg's book on Soviet space programmes attempts to take us behind the scenes. Of course, this is somewhat difficult considering the nature of Soviet secrecy but he does have the knack of bringing out little-known facts, although he is always particularly careful in pointing out what is speculation as opposed to fact. His thoughts on manned Soviet Moonshots are particularly interesting.

Above all, it is highly readable. Fascinating information is presented in an easygoing journalistic style – his description of Voskhod 2 cosmonaut Leonov fighting off wolves after landing in a forest is an example.

We are taken through the space programmes (primarily manned) from Sputnik 1, Gagarin (his manual controls were locked so that he could not touch them, with the secret combination hiding in an envelope stuck to the cabin wall!), Voskhod, the Soyuz 1 accident and Salyut. He concludes with a look at what the future may bring: permanent space stations and shuttle craft.

A very useful volume, bringing together most of what we know about the "hidden" side of space exploration.

The Illustrated Encyclopedia of Space Technology: a Comprehensive History of Space Exploration
Principal author Kenneth Gatland, Salamander Books, 289pp. 1981, £11.95.

The arrangement of this volume consists of 21 chapters, each on a topic such as space pioneers, space centres, man in space, military systems, Earth observation, men on the Moon, ASTP, Shuttle, etc. The last six chapters look ahead: flight to Mars, space factories, solar power satellites, Moon bases, space cities, and starships.

The authors are all familiar to *Spaceflight* readers: Ken Gatland, Boris Belitzky, Alan Bond, Nicholas Johnson, Bob Parkinson, Theo

Most of the above notes are not Reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

Pirard, Mitch Sharpe, Dave Dooling and others. Also included are an inspiring foreword by Arthur C. Clarke, a space diary listing every significant event including all manned flights, a glossary, a list giving details of the world's launch vehicles (on the endpapers, and very comprehensive: it even includes the private ventures of OTRAG and Bob Traux), and an index. The last follows the publisher's practice of lists under heavy-type headings like "Extra Vehicular Activities," "Materials," "Moon," "Rocket fuels," "Rocket motors," "Rockets" (a long list!), "Satellite and spacecraft launch vehicles," etc.

Another feature common with others in the series is the magnificent illustrations, including 20 two-page spreads showing, often in cutaway, such things as early rocket designs, Vostok and Mercury, Apollo, ASTP, and the Shuttle, as well as – a particular feature of the series – two enormous fold-outs, one showing 53 launchers to scale, and the other cutaways of Skylab and Salyut 6. There are also countless other illustrations – almost every page has at least one – photographs, drawings and maps, nearly all in colour. They include the first published maps of the Soviet and Chinese launch sites.

The BIS gets frequent mention, as one might expect given the identity of the principal author. References include early designs and studies, an item in the Space Diary on the move to the new Headquarters (with a photograph of Len Carter and Arthur Clarke!), and Alan Bond's chapter on "Starships," which is mostly about Project Daedalus (again, not surprisingly, since he was the Project Leader of the Study Group and a principal contributor to its report), with another splendid cutaway drawing.

Some chapters have references, some not. I doubt that a work of this kind needs them at all, but if we are to have them, let them be presented consistently: these are not. One chapter (3) has two sets of references, one (p. 38) giving authors' names inverted ("Ley, Willy"), the other (p. 43) giving them in direct order ("George M. Low"); also, the latter gives page references, the former does not. They should also be right – the editor of *Apollo Expeditions to the Moon* (p. 167) is called Cortright, not Cartwright.

A caption on p. 29 confuses the name of the satellite, Explorer 1, with the launcher, Juno I. J. D. Bernal's *The World, the Flesh and the Devil* (p. 261) is not a novel. The glossary contains the entry: "Descent module See Re-entry Module", but there is no entry under "Re-entry Module"; it also misspells "ephemeris" as "Ephermeris", and includes an entry "Light year" which gives the speed of light but not the distance meant by a light year – presumably one is meant to work it out for oneself from the information given! The Space Diary has "(C)" following the names of many spacemen: this is nowhere explained, and it took some time before I realised it meant "civilian". And I am grateful to G. Davies of Neath, West Glamorgan, for pointing out that on p. 123 there is an incorrect definition of deuterium!

Measurements are given in imperial units with metric equivalents in brackets, though it looks rather silly when an imperial figure which is obviously an approximation is rendered exactly into metric, e.g., one of Goddard's rockets is said to have come down "9,000 ft (2,743 m) from the launch tower" (p. 17).

The excellence of the editing, producing a coherent work rather than a collection of separate contributions, is shown by the frequent references from one chapter to another, though they are by different authors.

All in all, the interest of the text, the excellence of the illustrations, and the great reference value of the Space Diary, the table of launchers, and the other tables, make this a work of lasting value which should be indispensable to all space enthusiasts. Finally, at a time when a normal-sized hardback novel can cost nearly £8, such a price for a large-format book of over 280 pages, crammed with colour illustrations, is a tremendous bargain!

RAY WARD

The Quasar Controversy Resolved
F. Hoyle, University College Cardiff Press, 80 pp. 1981, £3.25.

Quasars have long been the subject of controversy since their discovery in the early 1960's. These objects have a star-like appearance when seen directly in telescopes but they have spectra quite unlike those of stars – they are highly red-shifted.

The cause of this shift may be the expansion of the Universe, local motion or gravitational effects. The first explanation has held sway for years but Hoyle argues that it is wrong – he labels it "devastatingly wrong." The second or some other, unknown, cause is more likely.

This is not an academic volume but a readable run-down on quasar theories and the controversies they have caused. It clearly leans in the direction of the author's theories (not surprisingly since he has been involved with the quasar story from the outset) and the title leaves little room for compromise. For all that it is a good, down-to-Earth introduction to those who may wish to learn more on the subject.

Shuttle/Spacelab: The New Transportation System and its Utilization
Eds. K. E. Koelle and G. V. Butler, Univelt, Inc. & DGLR, 329pp. 1981, DM 78.

This book, volume 43 in the series on "Advances in the Astronautical Sciences", reprints the papers presented at a joint meeting organized by the DGLR and AAS in Germany in 1980. A total of 23 papers are included.

In spite of the fact that the meeting took place while the Shuttle was beset with delays, enthusiasm for the programme was made abundantly clear.

The papers presented during the first four sessions provided a comprehensive status report on the utilisation of the Shuttle and related systems, Spacelab development and other major Shuttle Payloads, besides many of the experiments which are to use Spacelab for in-situ Space research.

Papers in the final session provided insights on advanced systems, particularly Solar Electric Propulsion, and other operational systems.

Reproduction has been made directly from the original texts, hence some uneven presentation, but the process has much to commend it in terms of speed and economy.

Daytime Star – The Story of Our Sun
S. Mitton, Faber & Faber, 190pp. 1981, £10.00.

The Sun has always fascinated mankind. This book provides an account of our present knowledge of this near star, its internal properties and its relation to other stars. It also explains, without the use of mathematics, how various solar phenomena probably arise and how these affect the Earth.

After a survey of work of early astronomers, followed then by an account of the basic working of the Sun and its life cycle, the book moves into the modern age by investigating some more recent data, such as that obtained from the Skylab mission.

Selected topics discussed include the solar neutrino problem, climatic change and solar activity. The last chapter of the book discusses solar energy and a global energy policy for the Earth.

The New Solar System
Ed. J. K. Beatty, B. O'Leary & A. Chaikin, Cambridge University Press, 224pp. 1981, £9.95.

The explanation of the title, i.e. what is the new Solar System and how does it differ from the old one is explained as being one now seen close up – probed by interplanetary spacecraft which have sampled the atmospheres of other worlds, tasted their soils, and passed through oceans of electrically-charged particles.

All of the objects within our Solar System have now become available for direct exploration, rather than passive observation. For the first time in human history, possibly, we understand – at least in outline if not in detail – something of how the Solar System came to be and how some of its bodies evolved.

All this knowledge has been gathered in a remarkably short time. The growth began in the 1940s and continued to the present day, swelled with the spectacular Voyager 1 and 2 flybys.

This book summarizes the fruits from the first decades of space exploration. It takes the form of a number of contributions from experimenters who conceived the missions, designed the experiments and analyzed the data. All the contributions are relatively short but the result is up to date as one could reasonably wish for.

The Planet Jupiter
B. M. Peek, Faber & Faber, 240pp. 1981, £10.00.

When the first edition of this book was produced in 1958 it was recognised, at once, as a volume which filled a most important gap in the astronomical literature.

In general, the aim of author, now deceased (this edition has been rewritten by Patrick Moore) was to make it a record as complete as possible, up to around 1948. References to many of the tables shows that this is still generally the case.

The addition of a sub-title "The Observer's Handbook" makes it clear that the aim is not to present purely detailed updated information on the planet Jupiter and its satellites but, rather, to re-introduce a book to amateurs wishing to make observations for themselves.

For this reason the present revised edition continues to devote the major part of its space to observations of the Jovian surface from the point of view of the amateur, including such items as optical observations of colour, belts and the different zones.

Of course, observations of the cloud surface of Jupiter have enormously improved with the successful Voyager missions, yet the planet is still one scanned assiduously by amateur observers.

Between Sputnik and the Shuttle
Ed. F. C. Durant, III, American Astronautical Society, 333pp. 1981, $40 (hard covers) ($30.00 soft covers).

This is an astronautics history publication with a difference, particularly as, following a short introduction by the Editor, the volume launches at once into a discussion of six Presidents of the United States and their attitudes to space, history so close as to be almost current news! This is followed by six main papers, most of which are concerned with American politico-economic space experiences, and ending with a short personal survey by the Editor of the field of space art. It was nice, but unusual, to see that this includes a reproduction of the drawing of the Leonid meteor shower in 1833.

This book is Vol. 3 in the AAS history series.

The Shape of Wars to Come
D. Baker, Patrick Stephens Ltd., 177pp. 1981, £8.95.

Ever since man first conquered Space his new abilities had a dual potential. Not only is there now a powerful new tool with which to expand our knowledge and experience of the universe, but also a vast potential to exploit Space for military purposes.

This book explores the history of man in Space and traces the development of military applications of space technology.

The development of surveillance satellites, meteorological satellites, killersats and all the rest is covered in great detail, though the most frightening part of this book lies in its examination of future developments.

Laser guns and particle beam weapons are no longer matters for speculation. It is now possible that a particle beam weapon, mounted on a suitable space platform, could circle the Earth ready to fire at an enemy below. Such a device, unlike nuclear weapons, would destroy all life and leave a world inhabited only by mutant insects.

This book traces the evolution of intelligence awareness in the directed-energy weapons field and shows how, piece by piece, an understanding of Soviet pre-eminence in this area has emerged. It traces the full twenty five year story of military space activity and describes projects only now coming to the drawing board.

The volume is not only concerned with lasers and particle beam weapons, but also with the new and expanding family of satellites which will be able to conduct electronic warfare in the 1990s. It also has a complete package of projections about new and applications for the Shuttle.

The author contends that a country which ignores the post-nuclear age of directed-energy weapons will find worse horrors awaiting. Far from toying with the existing and limited threats like cruise-missiles, those concerned about mass destruction should wake up to the realities of a science which has moved on.

Space – Enhancing Technological Leadership
Ed. L. P. Creen, American Astronautical Society, 613pp. 1981, $65 (hard covers) ($50 soft covers).

The AAS can always be relied upon to produce interesting volumes, this, Vol. 44 in their "Advances of the Astronautical Sciences" series, being no exception.

A mine of information is contained in over 50 papers reproduced, as is usual in such volumes, direct from the original Authors' texts.

The main areas dealt with are communications and navigation, deep-space exploration, energy and space power, defence applications, remote sensing, materials processing, guidance & control, large space structures and space transportation, the latter being concerned, naturally, with the Shuttle.

It is very difficult – not to say unfair – to try to pick out papers found to be of particular interest, since these will – clearly – vary between reader and reader. However, the session on large space structures is probably the area most applicable to the term "high technology". This generic class includes large antennas and platforms, beginning with arrays to be deployed by the Shuttle and ending with the construction of habitable modules.

Telescopes for the 1980s
Eds. G. Burbidge and A. Hewitt, Annual Reviews, Inc., 275pp. 1981, $27.

This monograph contains accounts of the history, planning and completion of the latest generation of telescopes to be built in the US – a radio telescope, optical/infrared telescope, X-ray telescope, and the first Space Telescope.

Until the 1940s, practically all observational astronomy was restricted to the optical wavelengths – between about 3,000 and 7,000 Angstroms. Advances made in the first half of this century nearly all stemmed from the construction of large reflectors and their use in good climates, plus the steady improvement in the quality of auxiliary equipment, particularly photographic emulsions.

The 35 years following the end of World War II saw the construction of many more large reflecting telescopes including the 100-inch Isaac Newton Telescope planned for use, of all places, "practically at sea level in Southern England"; nearly 30 years later, this incredible mistake was tacitly admitted by moving the telescope to the Canary Islands!

By the 1980s, a new level was reached in radio, infra-red optical, ultraviolet and X-ray astronomy. The articles in this monograph describe research available to the latest generation of telescopes, two of which are ground-based projects and two are space telescopes.

The authors of these contributions are highly distinguished in their respective fields and have, themselves, made major contributions to the design and construction of the telescopes about which they write.

Lowell and Mars
W. G. Hoyt, University of Arizona Press, 376pp. 1976, $9.50.

Although the famous "canals" of Mars have receded in the public imagination, the place held by Lowell in studies of the planet remains unique. His drawings and books were of immense public interest and fuelled astronomical debate for decades.

It is astonishing to reflect that Lowell's provocative Martian theory was first promulgated in 1894: Lowell, himself, considered it completely and repeatedly confirmed by observations made by himself and others over fifteen years at an Observatory he founded in 1894, at Flagstaff in Arizona. Time, he was sure, would pave the way for full recognition of his work.

This is not a biography of the man in the ordinary sense, but rather a study of his ideas. Whether these were superficial or erroneous is beside the point: right or wrong, they stimulated other minds in turn.

This is quite a scholarly tome. It describes not only Lowell and his Observatory but his studies of Mars and the effect of his reports and their responses, based on original documents.

It is a fascinating story, well worth the telling, and served up here as a feast. A really good definitive work.

The Creation
P. W. Atkins, W. H. Freeman, 132pp. 1981, £5.95.

This is not a book about the nature and origin of the Universe i.e. there is no "big bang" or steady state theory here. The author is more concerned with a Universe which came into being because it could not fail to do so!

He holds the view that there is *nothing* that cannot be understood and believes that very simple structures can produce manifestations as rich in scope as people, planets, consciousness and freewill.

His chapter headings make the point succinctly i.e. why things change, how things change, where things change, and both creating and created things.

Comets
Various Contributors, W. H. Freeman, 92pp. 1981, £7.50 hardback (£3.50 paper).

This volume re-prints material which has previously appeared in the *Scientific American*, with an introduction by J. C. Brandt.

There are ten contributions altogether, all very short, but enhanced by 108 illustrations.

Particularly interesting, and very topical, is the account of the appearance of Halley's Comet in 1910. Before long, no doubt, this will be featured increasingly in the media, coupled with a frantic search to unearth drawings, photographs and accounts of earlier returns as illustrations of a fascinating past.

X-ray Astronomy
J. L. Culhane & P. W. Sanford, Faber and Faber, 192pp. 1981, £10.

X-ray astronomy began with observations of the Sun in 1949 using captured V2 rockets. These studies continued through the next decade using rockets and, later, orbiting satellites. In 1962 the first extra-solar source was discovered in a rocket flight and, in the next eight years, the many additional discoveries made from rockets greatly enlarged the scope of the subject.

Although the Sun is, of course, our nearest and most intense X-ray source, X-ray astronomy for the rest of the Universe, though still at an early stage, promises to yield results of fundamental importance for astrophysics and cosmology.

This book provides an ideal introduction to the subject both for the student and the interested amateur.

The Mysterious Universe
N. Henbest, Marshall Cavendish, 184pp, 1981, £8.95.

Not to be confused with Sir James Jean's famous epic of the same title, this book seeks to extend popular knowledge about the exploration of our Solar System and beyond.

The author begins with current theories on the birth of the Solar System, following this with a description of the various planets - including much up-dated Voyager material on the Jupiter and Saturn fly-bys. He then goes on to consider the birth and death of stars and the possibilities of life in the Universe, ending with sections on pulsars, black holes and quasars, leading to the "ultimate mystery" i.e., how the Universe was formed.

This is a large-format well-illustrated book, with many of pictures in colour.

A Dictionary of Astronomy
Ed. V. Illingworth, Pan, 378pp, 1981, £2.95.

This is one of the Pan reference paperbacks. It provides a comprehensive guide to most of the commonly-used terms in the astronomical world today.

All of the entries are cross-referenced and many illustrated with diagrams. It includes important terminology from space programmes down to the selection of relevant terms in physics and mathematics, along with a useful selection of tabulated data.

Planetary Satellites
Ed. J. A. Burns, University of Arizona Press, 598pp. 1977, $19.95.

This book is really a compound of information from 33 contributing authors and, although in need of update following the recent successful Voyager fly-bys, nevertheless contains an enormous amount of fundamental information which makes it of considerable interest.

After a brief introduction, the book launches into its main "meat" with a description of the orbits and dynamical evolution of natural satellites. The two following sections i.e. on the physical properties and characteristics of individual satellites is the section in which most progress has recently taken place and which are most in need of updating.

The final section, on the origin of satellites, still represents a valuable and cogent contribution to this discussion.

All in all, this is a book which is well worth reading. It is choc-a-block with information, authentic, easy to read and valuable for its information-content.

Applications of Space Developments
Ed. L. G. Napolitano, Pergamon Press, 350pp. 1981, £30.

This, the Proceedings of the 31st IAF Congress held in Tokyo in 1980, covers many of the most recent advances in the development and utilisation of space and technology for Earth-orientated applications.

The volume reproduces only selected papers from the Congress, of course, notably on the themes of Space and Energy, Earth-orientated Applications and the Low-gravity Environment.

Subject matters dealt with in detail included Monitoring the Earth and Ocean Energy Resources, Earth Satellite Power Stations, Energy Conversion and Transfer, the Structure and Fabrication and Assembly of Large Space Structures and, finally, the Disposal of Nuclear Waste in Space.

Particular matters covered are Weather Satellites, Earth and Ocean Dynamics, Atmospheric Pollution and Data Analysis, with another section on theoretical and experimental aspects of Micro-gravity Materials, Fluid and Life Sciences and the Simulation of a Micro-gravity Environment on Earth.

Concluding matters dealt with included Space Communications, with emphasis on economic aspects, and on the prospects for TV Satellites.

A total of 22 papers are listed: all, except one, are in English.

Utilization of Outer Space and International Law
G. C. M. Reijnen, Elsevier Scientific Publishing, 179pp. 1981, $63.85.

The present volume continues the theme discussed earlier in a book entitled "Legal Aspects of Outer Space" (1977) but examines the matter in greater depth, particularly the utilization of outer space.

The definition of "outer space" covers the region suggested by ICSU i.e. from a 100 km to 384,000 km, the latter corresponding to the distance of the Moon. Beyond that, the definition becomes one of "deep space".

The point of all this is that international law relating to space applies equally to outer space and to deep space so, by definition, it would seem to apply to anything more than a 100 km above the Earth's surface.

The development of space utilization, including increasing applications for military purposes, has had the effect of showing all too clearly that the "Law" is falling some way behind. This book tends to plug the gap, to some extent, by highlighting some of the many intricate problems which space lawyers need to face in trying to solve these problems, not least because Politics is Big Brother and Space Law quite diminutive, by comparison.

As might be expected, legal aspects are very much concerned with definitions so it is not surprising that the volume begins with the concept of the term "Sovereignty" and the problem as to whether international organisations are sovereign or not.

The book *The Quest For Extraterrestrial Life - A Book of Readings* reviewed on p.327 of the November 1981 issue of *Spaceflight* is now available from the publisher John Wiley & Sons, price £8.00.

NOTICES OF MEETINGS

Study Course

Theme: **REMOTE SENSING**

The final two meeetings of the Study Course on the above topic take place in 1982:

17 February 1982 — Remote Sensing by Landsat and Weather Satellites.
by Dr. R. Harris
University of Durham

10 March 1982 — Evening of Technical Films on Remote Sensing.

The venue will be the Society's Conference Room at 27/29 South Lambeth Road, London SW8 1SZ. Lectures will run from 7.00-9.00 p.m. Course Fee £3.00.

Applications forms for registration available from the Executive Secretary. Please send s.a.e.

Discussion

Theme: **MANNED EXPLORATION OF THE PLANETS**

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **13 January 1982,** 7.00-9.00 p.m.

The Space Technology Committee has organised this meeting to discuss the near-term possibility of manned exploration of the Inner Solar System, as part of its plan to form a study group to give the matter more detailed consideration.

Invited speakers will give a few short talks, followed by discussion.

Admission is by Ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Lecture

Title: **STARS – THE SOURCE OF LIFE**

by C. A. Whyte
University of Cambridge

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **20 January 1982,** 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Lecture

Title: **RECENT ADVANCES IN OUR KNOWLEDGE OF THE SUN**

by Dr. G. O. Gough
University of Cambridge

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **27 January 1982,** 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Lecture

Title: **THE RETURN OF HALLEY'S COMET**

by M. J. Hendrie

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **10 February 1982,** 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Film Show

Theme: **SPACE SATELLITES**

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **24 February 1982,** 7.00-9.00 p.m.

The programme will include the following:

(a) Landsat: Satellite for All Seasons
(b) Navigation Satellite Project
(c) Discovery in Space
(d) Streetcar (OGO)
(e) Electric Power Generation in Space
(f) Orbiting Solar Observatory

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Lecture

Title: **THE 1950's POPULARIZATION OF SPACE TRAVEL**

by A. B. Perkins

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **11 March 1982,** 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Film show

Theme: **THE MAKING OF AN ASTRONAUT (PART III)**

Films covering the development of manned space voyages will be screened at a meeting to be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **24 March 1982,** 7.00-9.00 p.m.

The programme will include the following:

(a) Four Rooms, Earth View
(b) Space Shuttle (1977)
(c) Space Shuttle, Overview (1980)
(d) Space Shuttle, Mission to the Future (1981)
(e) STS-1, Post-flight Conference

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Lecture

Title: **THE STABILITY OF THE SOLAR SYSTEM**

by Prof. A. E. Roy
University of Glasgow

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **7 April 1982,** 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Symposium

Theme: **SPACE TRANSPORTATION SYSTEMS FOR THE 1980's**

Organised by P. J. Conchie

Offers of papers for presentation at a one-day meeting to be held in the Society's Conference Room, Society HQ, 27/29 South Lambeth Road, London, SW8 1SZ, on **20 April 1982,** 7.00-9.00 p.m.

Registration Forms and copies of the Final Programme will be available from the Executive Secretary in due course. Please enclose a reply-paid envelope with request.

Lecture

Title: **THE TURBULENT SUN**

by Dr. G. M. Simnett
University of Birmingham

Continued on back cover

SPACEFLIGHT

Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 27/29 South Lambeth Road, London SW8 1SZ Tel: 01-735 3160

Correspondence and manuscripts intended for publication should be addressed to the Editor, 27/29 South Lambeth Road, London SW8 1SZ.

Opinions in signed articles are those of contributors and do not necessarily reflect the views of the Editor or the Council of the British Interplanetary Society, unless such is expressly stated to be the case.

Continued from inside back cover

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **5 May 1982**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Film Show

Theme: **STEPS TO THE MOON – 1**

A series of film programmes to sketch the story of man's Exploration of the Moon. The first will be screened at a meeting to be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **6 October 1982**, 7-8.30 p.m.

The programme will include the following:

(a) Destination Moon — The Story of Project Ranger
(b) Close Up — A Look at Lunar orbiter
(c) Project Apollo: Manned Flight to the Moon
(d) Steps to Saturn
(e) Landing on the Moon

Admission is by ticket only. Members wishing to attend should apply in good time, to the Executive Secretary, enclosing a stamped addressed envelope.

Film Show

Theme: **STEPS TO THE MOON – 2**

The second programme in this series will be screened at a meeting to be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **27 October 1982**, 7.00-9.00 p.m.

The programme will include the following:

(a) Assignment Shoot the Moon
(b) Apollo/Saturn V Lunar Mission
(c) Debrief Apollo 8
(d) Apollo 9 - The Duet of Spider and Gumdrop
(e) Apollo 10: Green Light for a Lunar Landing

Admission is by ticket only. Members wishing to attend should apply in good time, to the Executive Secretary, enclosing a reply-paid envelope.

Film show

Theme: **STEPS TO THE MOON – 3**

The third programme in this series will be screened at a meeting to be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **17 November 1982**, 7.00-9.00 p.m.

The programme will include

(a) Apollo 11 — Eagle Has Landed
(b) Apollo 12 — Pinpoint for Science
(c) Apollo 13 — Houston, We've Got a Problem!
(d) Apollo 14 — Mission to Fra Mauro
(e) Apollo 15 — The Mountains of the Moon

Admission is by ticket only. Members wishing to attend should apply in good time, to the Executive Secretary, enclosing a reply-paid envelope.

Film Show

Theme: **STEPS TO THE MOON – 4**

The final meeting in this series will be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **8 December 1982**, 7.00-9.00 p.m.

The programme will include the following:

(a) Apollo 16 — Nothing So Hidden
(b) Apollo 17 — On the Shoulders of Giants
(c) The World Was There
(d) The Time of the Apollo

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

SOCIETY EDUCATIONAL TOURS

Halley's Comet — April 1986 — 10 days duration

Owing to the likelihood that Halley's Comet will prove to be a disappointing object when viewed from the Northern Hemisphere, if it can be seen at all, the Society plans to organise a trip to South Africa to view the comet from the Southern Hemisphere. Present indications are that the most favourable time will be the first week in April 1986.

The Society will arrange travel and motel accomodation at the best possible rates.

Members interested in participating in this trip are asked to send preliminary notification to the Executive Secretary.

OUR SPACE LIBRARY

The Library will be open to members from 5.30-7.00 p.m. on each of the following dates:

13 Jan. 1982	20 Jan. 1982
27 Jan. 1982	10 Feb. 1982
24 Feb. 1982	10 Mar. 1982

While every effort will be made to adhere to the published programme, the Society cannot be held responsible for any changes made necessary for reasons outside its control.

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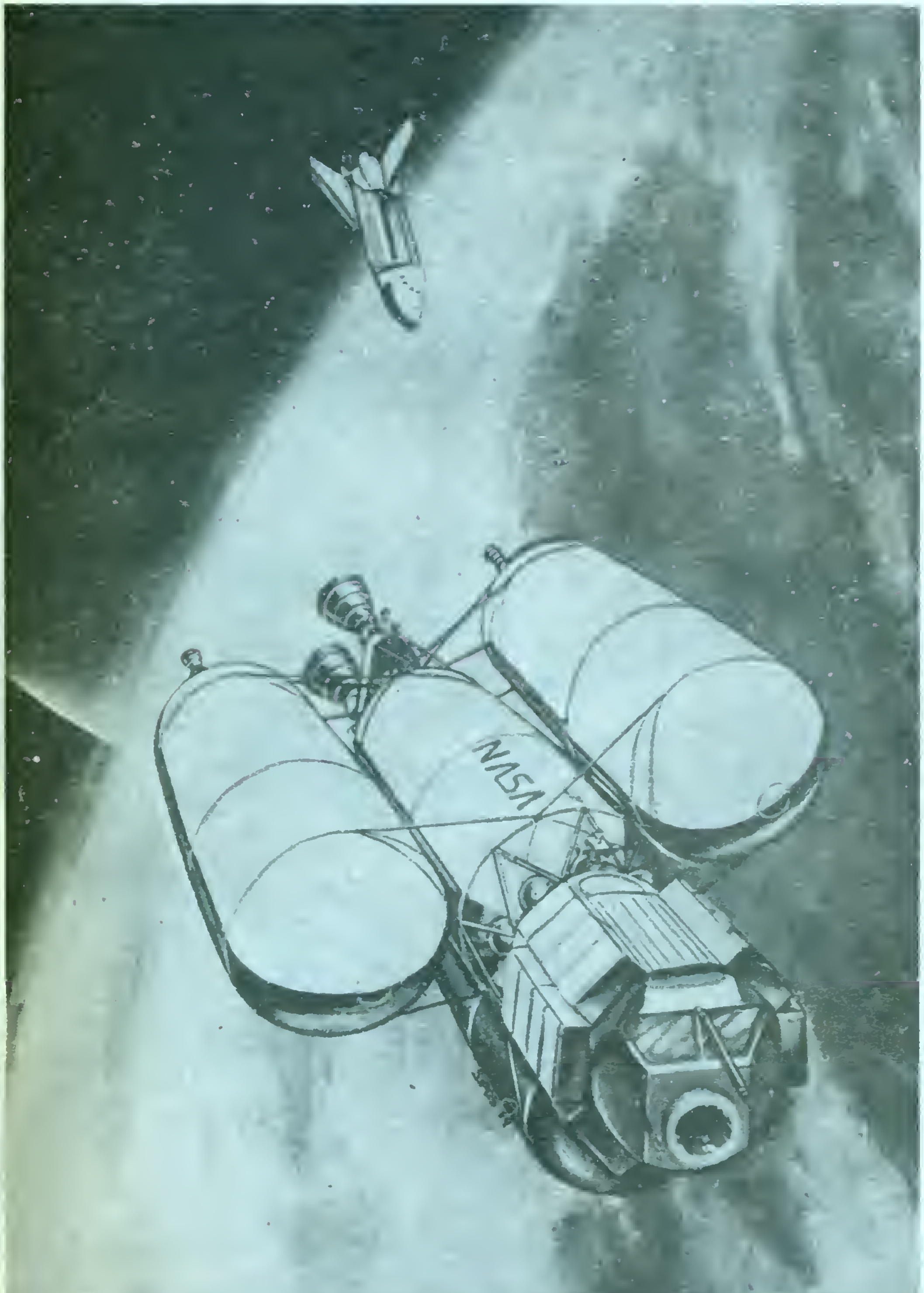
SPACEFLIGHT

88905 Космические полеты № Т-3
(спейсфлайт)
По подписке 1982 г.



Published by
The British Interplanetary Society

VOLUME 24 No. 3
MARCH 1982

NOW AT BRIGHTON!

SPACE '82 THE FUTURE OF MANKIND

Space '82 is planned to be bigger and better. As a final step, we have been seeking a much improved venue and we have found it! It will be at the new Brighton Conference Centre, purpose-built to meet the needs of conferences. It is equipped with every modern facility and is also close to the famous Regency Pavilion, which we now intend to include in some of our functions.

Brighton Corporation have agreed to provide a wide range of hotel accomodation on our behalf and to deal with all the formalities. All that members will need to do is to complete a simple form indicating their requirements and the price range they have in mind – the scope of facilities at Brighton is so great that almost everyone should find something to their satisfaction.

An added attraction is that all participants will be invited to an opening Reception in the Regency Pavilion as guests of Brighton Corporation and the Society.

We now have access to excellent display facilities to produce an even more exciting programme – one that members simply will not wish to miss. Make a note and join us in Brighton on **12–14 November 1982**.

Our programme is developing all the time but here is a basic description of how things stand at present:

Alan Bean, Apollo and Skylab astronaut, will be one of our guests at Space '82.

12 November (Friday)

Registration in the early evening is followed by an informal buffet supper with our President and Martin Fry, Space '82 organiser, who will welcome visitors and introduce some of our special guests.

13 November (Saturday)

This will be a very full day indeed.

Part of our programme includes: Dr. T. O. Paine (ex-NASA Administrator) and Raefe Shelton of British Aerospace posing the question: *The Energy Problem – Can Solar Power Satellites Provide the Answer?* Cene Roddenberry of "Star Trek" fame will speak on *Space: A Vision of the Future*, and Burt Edelson (COMSAT Vice-President) will consider *Space Communications – The Universe at Our Fingertips*. A session on *Into Deep Space* will discuss exploration of the deeper recesses of Space.

Breaks for coffee and lunch will give visitors the chance to mingle with our distinguished guests and see some of the displays (ESA have agreed to provide a collection of models).

An informal evening banquet will conclude the day. Some of our guest speakers will be Ted Mallet who will talk on *Europe in Space* and Rex Turner who will reflect on *The Society, Soon 50 Years Old – A Look Ahead.*

Ted Mallet of ESA will talk about "Europe in Space" at Space '82.

14 November (Sunday)

Sessions will include speakers such as Dr. Cary Hunt (*Exploration of the Solar System*), Dr. Bill McLaughlin of JPL (*Evolution of Man and Machine*), and Capt. R. F. Freitag of NASA (*Space Industrialisation*).

This is only part of our basic programme. There will be many additions in the coming months to make this a not-to-be-missed event.

Registration forms are available on request. A fully detailed brochure will be available and will be sent automatically, to those who have expressed interest in it. Applicants from now on should enclose a 20p stamp.

SPACEFLIGHT

A Publication of The British Interplanetary Society

Founded 1933 *Incorporated 1946*

VOLUME 24 No. 3 MARCH 1982 *Published 15 February 1982*

CONTENTS

98 **Prospects For Interplanetary Exploration** *Dr. R. G. Parkinson*

103 **STS-2: A Mission Almost Accomplished**

112 **News From The Cape** *Gordon L. Harris*

119 **Reusable Satellite Platforms** *D. E. Koelle*

124 **Space Report**

128 **Space Communications**

129 **Training For Space** *Gerald L. Borrowman*

133 **Percheron – A Space Workhorse** *Paul D. Maley*

136 **Satellite Digest – 152** *Robert D. Christy*

140 **Society Meetings**

142 **Book Reviews**

COVER

A PROPOSAL FOR a manned orbital transfer vehicle which would be launched by the Shuttle in the late 1980's. This version would require four standard Shuttle launches to assemble the vehicle and supply its two-man crew for a trip to geosynchronous Earth orbit (GEO) where it could repair and service four communications satellites. Two manipulators and a satellite "grabber" can be seen in front of the crew cabin, as well as a docking port. The craft would then return to its original low orbit, 19 days after leaving, and the crew could transfer back into the Shuttle to return home.

Grumman Aerospace

MILESTONES

November 1981

17 Veneras 13 & 14, heading for Venus encounter next March, have travelled 4 and 3 million miles, respectively. Course corrections were made on 10 and 14 November, respectively.

19 The RCA Satcom 3R communications satellite is launched successfully by a Delta 3910. It will move into a geosynchronous position at 132 degrees west longitude. The original Satcom 3 was lost after its apogee boost motor fired.

20 The Indian satellite Bhaskara 2, carrying cameras and radiometer instruments, is launched by the Soviets from Kapustin Yar into a 300 mile orbit.

20 The Soviet Union has so far this year launched a total of 92 missions into space (some of them carrying multiple payloads).

25 Shuttle Orbiter *Columbia* arrives back at the Kennedy Space Center after its ferry flight back from California atop its 747 transporter. An overnight stop at Bergstrom AFB in Texas was included. About a dozen damaged tiles were removed for the trip and replaced by temporary foam inserts. In early December, NASA issues a tentative launch schedule of: STS-3, week beginning 22 March; STS-4, 7 July; STS-5, 1 November; STS-6, 6 December. Orbiter *Challenger* will be first used on mission 6.

30 Cosmos 1267, docked with Salyut 6 since 19 June 1981 and described by the Soviets as a space station module, is equipped with clusters of "antisatellite interceptor vehicles", according to *Aviation Week*. They are "1 m long miniature vehicles guided by infrared sensors".

December 1981

4 The Spacelab pressurized module for the first mission, in September 1983, is formally handed over to NASA representatives at the ERNO facilities in Bremen, West Germany. The module and one pallet are due to arrive at the Kennedy Space Center on 11 December.

15 The third Intelsat V communications satellite, capable of handling more than 12,000 simultaneous telephone calls, is launched by Atlas Centaur from Cape Canaveral.

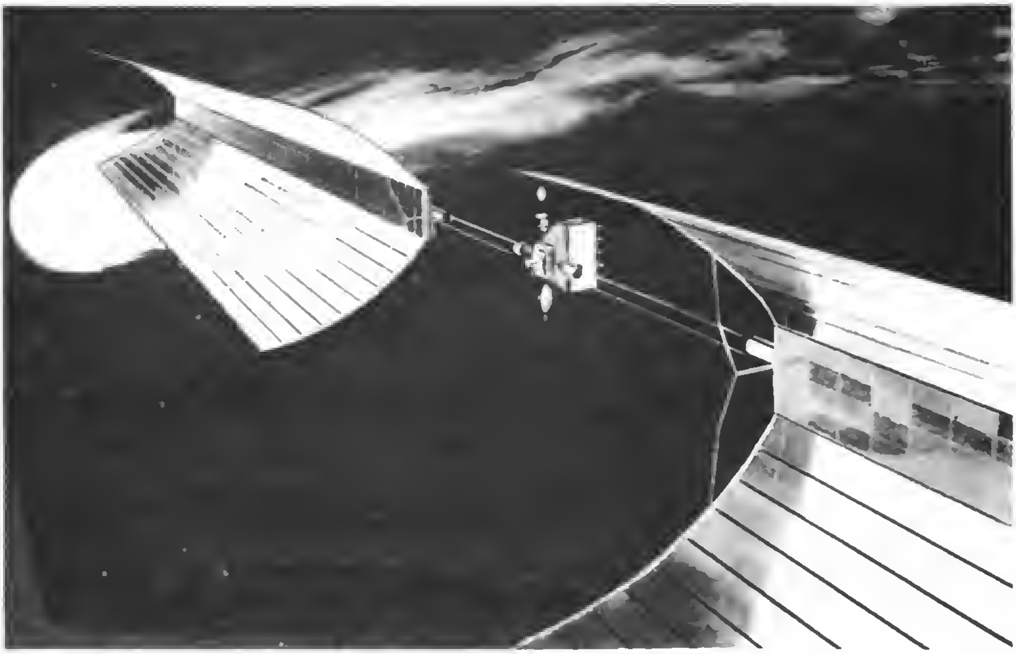
15 Intelsat announces that it will launch two of its three final Intelsat V communications satellites on the European Ariane vehicle. An Intelsat Board of Governors meeting in Washington, D.C. decided to order one further Atlas-Centaur (so far the only launcher of the satellite) pending further clarification on the possible use of the Shuttle, and two Arianes. Cost for all three is expected to be around $154 million. The next generation satellite, Intelsat VI, will also be compatible with Ariane.

20 The fourth and final test launch of Ariane, L04, takes place from Kourou at 01.29 GMT, with ESA and CNES describing it as a "complete success". (Problems arose with the liquid oxygen feed valve plates of the third stage on 16 December, forcing repairs the next day, followed by leak tests.) After the separation of the Marecs maritime communications satellite from the launcher, the Operations Control Centre, located at the European Space Operations Centre (ESOC) in Darmstadt, West Germany, telecommanded a number of manoeuvres designed to stabilise the spacecraft in its highly elliptical orbit. The Apogee Boost Motor (ABM) was fired for 30 seconds on command from the Operations Control Centre at 14.13.19 GMT on Monday, 21 December. Initial assessment shows that the orbit achieved corresponds very closely to the objectives and that the satellite is now drifting towards its nominal position in geosynchronous orbit at 26 degrees W. After an initial period of testing, the satellite will, early in 1982, be handed over to the INMARSAT organisation to become part of its global network.

T 2

PROSPECTS FOR INTERPLANETARY EXPLORATION

By Dr R. G. Parkinson



Electric propulsion was proposed for a US probe to Tempel 2 and Halley's Comet this decade, but fell by the wayside. Nevertheless, this kind of approach may well be adopted fc· future Solar System exploration.

NASA

Introduction

The future may see the 1970's as the first golden age of planetary exploration. Mariner 9 and later Viking revealed the complex world of Mars to our gaze. Venus was unveiled by Pioneers 12 & 13, and the Russian Venera probes. Mariner 10 made three close approaches to Mercury in a game of interplanetary billiards. And Pioneers 10 & 11, followed by the two Voyager spacecraft, revealed the diverse worlds of Jupiter and Saturn and their attendant satellite systems.

The Solar System has proved to be a far more interesting place than we had imagined. True, there were no green men on Mars, nor hot swamps beneath the clouds of Venus, but neither were these other worlds mere dull and barren repetitions of what we had discovered on the Moon.

By contrast, the 1980's have opened with a paucity of planned missions. The Europeans have actually become more active than the Americans, with Giotto planned for Halley's comet, active funding of their International Solar Polar Mission spacecraft, and German participation in the US Galileo probe to Jupiter. Only the Venus Orbiting Imaging Radar is a wholly US mission. And beyond those missions there are only proposals and studies. However, absence of missions is not due to absence of targets. Indeed, the very variety of targets may be making planning more difficult.

Mars is a good example. Follow-on missions to Viking have proposed a polar geophysical satellite, surface rovers, subsurface penetrators, robot aircraft with a planet-wide range, and surface sample return missions similar to Luna 16. The Mars Science Study Group highlighted the most expensive of these - surface sample return - as being of the greatest value, but there is no doubt that even this would only provide a small fraction of the information we would like to know about our neighbour planet. And in the absence of funding for a surface sample return mission, the next Mars mission (possibly an ESA funded mission) is likely to choose one of the lesser options.

These sort of considerations led the author to re-examine the prospects for a manned mission to Mars in the mid-1990's [1] which could carry out a comprehensive survey of the planet. The conclusion of that study was that, using the hardware that might be available by the end of the century, such a comprehensive mission actually be more cost-effective than a series of specialised robot probes.

This conclusion may have wider implications for the long-term exploration of the Solar System. With developments for operations in near-Earth space - launching heavy platforms into geostationary orbit and carrying out orbital construction - the space transportation technology of the early twenty-first century may well favour launches of single, comprehensively equipped missions to individual planetary *systems* rather than a succession of specialised smaller craft. This article is a personal speculation on some of the proposals and some of the possibilities. It will deliberately omit further consideration of Mars, but will look at the rest of the Solar System.

First Choice - Men or Robots?

Until now it has always been cheaper to send robots on interplanetary missions. Robots are less demanding on life support systems than men, and they do not need to be brought back at the end of the mission. Furthermore, their senses are more sensitive than the human eyeball, and so even manned missions need to carry a great deal of instrumentation.

At the same time, robots are less adaptable. Even at the relatively close range of the Moon, the Russian Lunokhod was very much less mobile than the Apollo astronauts. At longer ranges direct human control is not possible due to the long communications lags involved. A great deal of work has gone into devising computer systems which could guide a Mars surface rover and prevent it from falling into holes and ravines which would have been avoided by quite humble animal intelligence. But this work is not yet complete, and if we have to devise adaptive systems capable of surveying, selecting and moving about the complex satellite systems of the Outer Planets, for example, still more work will be required.

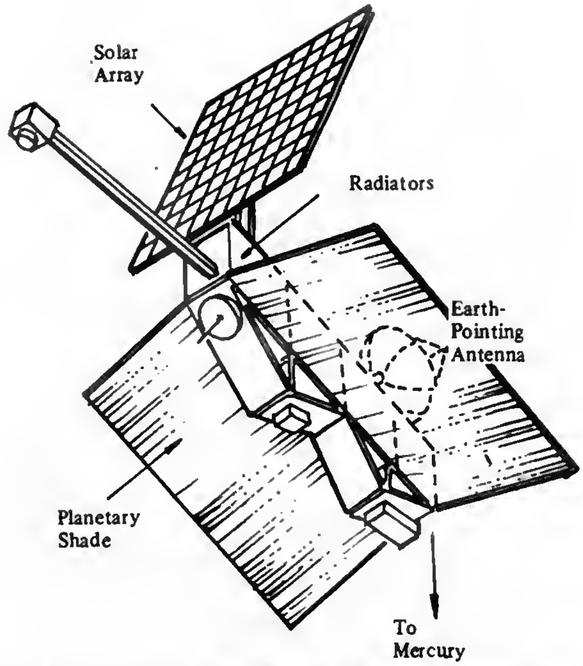
Admittedly the development of machine intelligence to this level would have many "spin offs" back home on Earth. Indeed, a recent NASA/ASEE study [2] suggested that Earth-directed research might well be ahead of NASA in this area, and that development of such robot exploration systems might form an important long range programme for NASA. But there are

other considerations. It is no longer true that robots do not have to come back.

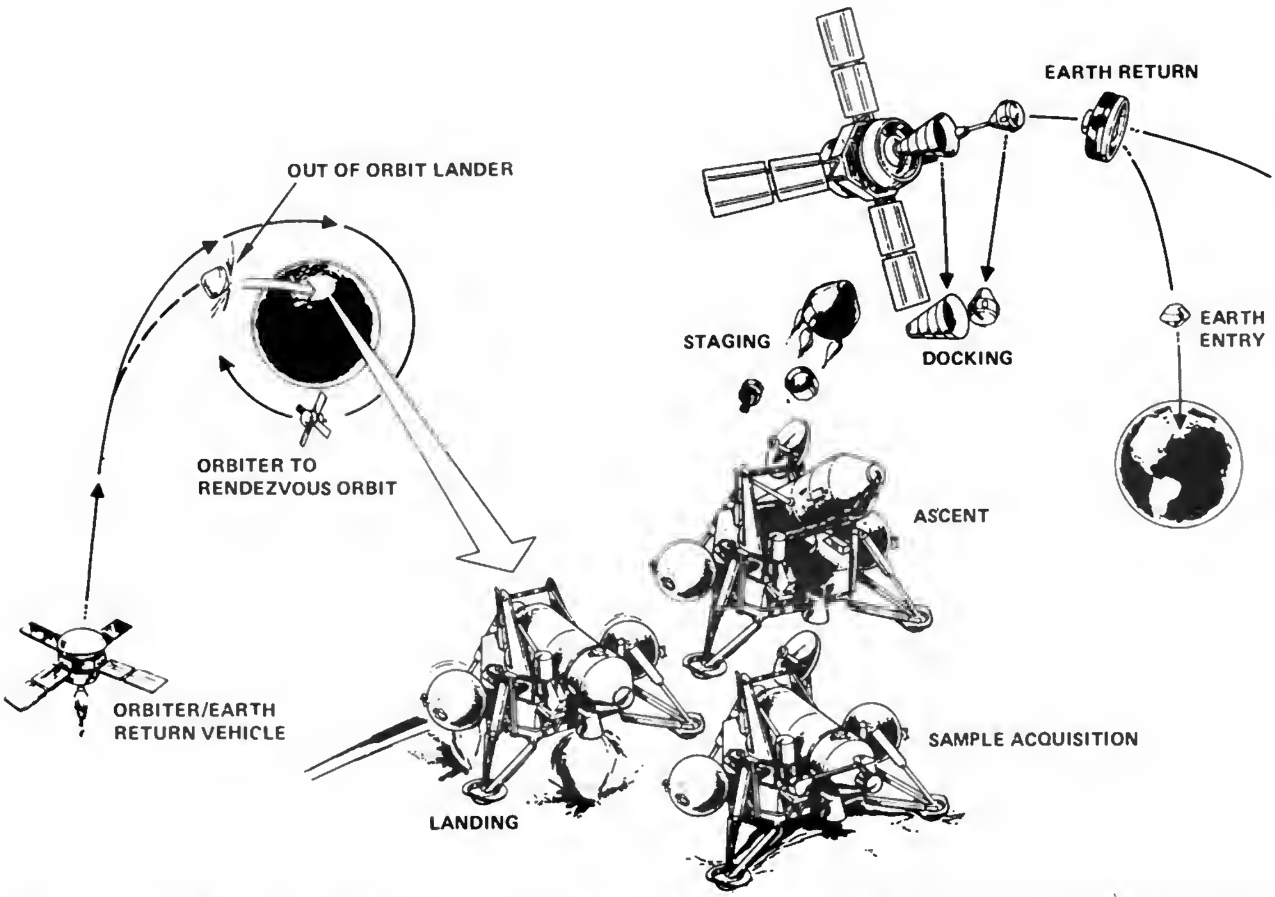
Apollo demonstrated the importance of surface sample return missions. While it is easy to make overall chemical and geological analyses of the local rocks on-site, a real understanding of the make-up of another world demands that samples be returned for study by the most advanced laboratory facilities available on Earth. Furthermore, on-site measurements do not lend themselves to follow-up measurements suggested by the original investigation. And to get maximum advantage from such samples, they should be selected from diverse sites over the target plant – often from sites which are not particularly optimum from the point of view of landing a probe. It may even be desirable to drill beneath the surface to reveal the inner structure of the planet. This all means that while robot missions may well remain smaller in mass than a manned mission, the robot probes will have to grow considerably in size and complexity.

Now, even with a Centaur upper stage, the throw mass of the Shuttle for interplanetary missions is essentially unchanged from that of the Titan/Centaur combination which launched Viking and Voyager. Much larger missions will demand improved operational concepts, improved propulsion systems, or on-orbit assembly of large vehicles.

Improved operational concepts can mean better mission planning. The gravitational fields of Jupiter and Venus have been used to boost spacecraft towards targets further from and closer to the Sun. I suspect that such gravitational swing-bys will become steadily more important, particularly if sample return missions are considered. One scheme originally proposed in the early 1970's for solar-electric missions [3], but

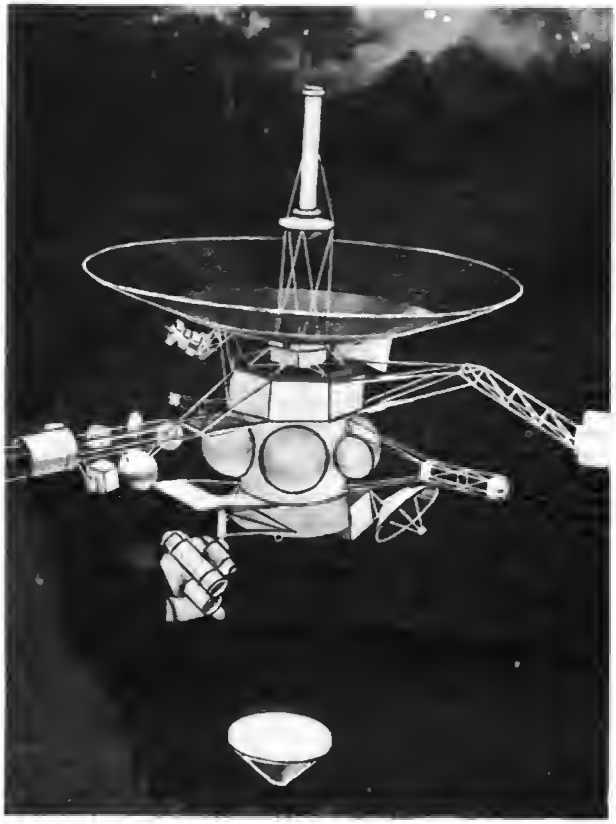


NASA/JPL concept for one spacecraft of a twin spacecraft Mercury orbiter mission. While solar power would be plentiful, keeping the spacecraft cool might be a problem. Direct radiation from the Sun is 10 times greater than at the distance of Earth's orbit, plus radiation would be reflected by Mercury itself.



Returning a sample of the planet Mars to Earth is an attractive, but difficult and expensive, mission. This NASA concept envisages a lander taking a sample up to an orbiter, before being despatched to Earth in a capsule.

NASA



The future of the Galileo Jupiter orbiter (shown here with the atmosphere entry probe at bottom) is uncertain; budget restrictions may force its cancellation.

NASA

which could have particular benefit for asteroid and comet-chasing missions out of the ecliptic, is to use an Earth swing-by: placing the spacecraft on an orbit which later returns to Earth at a somewhat different angle to gain a second boost towards its target. When home computer enthusiasts get tired of playing "Space Wars" this sort of problem may provide an added challenge.

Another concept being considered quite seriously is aero-braking. Instead of using chemical propulsion for the spacecraft capture at the target planet, the spacecraft is flown to graze the fringes of that planet's atmosphere to shed energy in a partial re-entry. While this technique could double the payload mass delivered, it demands extremely high precision navigation on the approach and an accurate knowledge of the structure of the planet's upper atmosphere [4].

Improved propulsion concepts seem now to be focussed on electric propulsion. NASA has been working on ion motor propulsion for two decades now, has demonstrated working motors in orbit and all of the associated technology, and only narrowly failed to get a solar-electric vehicle funded for the Halley comet mission. For outer planet missions a solar-electric vehicle is probably ineffective, and attention has focussed on nuclear-electric systems [5]. NASA has studies for a 400 kW nuclear electric stage which would allow multi-tonne payloads in orbit about the giant planets. The problem is that such a stage would be expensive, and is not likely to be developed for near-Earth operations, which means that it would probably have to be funded by the first mission to which it was applied.

Now let us look at some of the possible targets:

Asteroids and Comets

While we tend to think of the asteroids as lying "beyond Mars," some of them are actually the closest objects to approach Earth besides the Moon. Interest in such "Earth approaching" asteroids has been rekindled by the Space Colonizers, who see them as potential sources of raw material – possibly containing volatile and carboniferous materials. They are also possible targets for the amateur astronomy community, who can scan the heavens extensively in search of such "targets of opportunity."

However, the fact that they are relatively close to the Earth does not make these asteroids easy targets. Most have elliptical orbits which have significant inclinations to the plane of the ecliptic, and getting above the plane of the planets can be expensive in "delta-V." Earth and Venus swing-by trajectories may provide useful assistance in this area.

One target which has been studied already is the asteroid 1943 Anteros, which has an aphelion only 1.4 times the Earth's distance from the Sun, and an orbital inclination of 8.7°. Hulkower and Ross [6] have studied a possible rendezvous mission with a launch window in May 1985, which would allow a Titan 34D/IUS combination to deliver a 615 kg spacecraft to Anteros some 402-455 days later. Another launch window is available in 1987. The authors suggest a modified Tiros N as the proble vehicle carrying 50-100 kg of scientific instruments for our first close-up view of an asteroid.

Return missions to asteroids are likely to be more complex, because of the lack of synchronisation between the elliptical, inclined asteroid orbit and the Earth, but once again planetary swing-by manoeuvres may be the key. Some asteroids may be easier in this respect than others, because they are locked "in resonance" with the Earth, making regular close-approaches to our planet. The asteroid Toro is the best known of these.

If asteroids represent difficult targets, then comets are even worse. The ESA Giotto probe will pass Halley's comet at a relative speed of 60 km/sec, and will use real-time transmission to return its data *before* it enters the comet's tail, as it is not expected to survive afterwards. Missions to comets with shorter periods are easier, but less interesting, as these represent "old" comets that have lost much of their volatile material. Solar-electric propulsion would be useful to allow an approach to a true "rendezvous," but even here on-board intelligence and short communications times may be needed if the spacecraf is to manoeuvre accurately and "explore" the nucleus regic in detail.

For the long-term, and hence more interesting comets, the... is an even greater problem – such comets (with very few exceptions) are not predictable in advance. Only when one is detected on its way in to the Sun do we know that we have a target. For such missions it may be necessary to build the spacecraft in advance of the mission, "on spec" as it were, so that it can be launched quickly once a suitable target has been spotted and the mission plan computed. I can see some interesting political problems in funding such a mission.

Venus

Despite numerous missions to Venus, the true features of that planet have only just begun to appear from the scan provided by the radio-altimeter aboard Pioneer 12. The Venus Orbiting Imaging Radar spacecraft should provide us with a detailed map of the surface of Venus for the first time, but evidence already in shows an active world with rift valleys, meteor scars and possibly volcanoes.

Although it is the nearest planet to the Earth, Venus is going to be immensely difficult to explore. It is simple enough to observe it from orbit, or even to drop probes or balloons into the upper atmosphere, but any probe intended for the surface must be heavily insulated and protected against the high pressure atmosphere if it is to operate at all – even for a few minutes.

As far as I know, nobody has yet attempted to design a surface sample return mission for Venus, although such a mission would be of immense scientific interest. The orbital velocity which would have to be achieved by the ascent vehicle

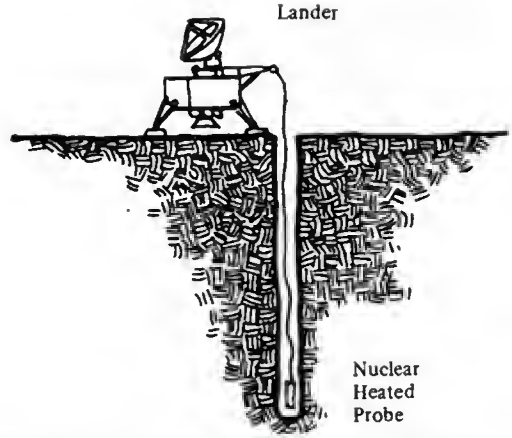
is less than that for Earth, and in terms of sample sizes considered for a Mars sample return mission a three-stage solid-propellant vehicle with a mass of about three tonnes would appear to be sufficient. The problem is, however, that this vehicle would first have to come up through 60 or 70 km of dense, hot atmosphere *slowly*. Balloons or ducted rockets might help, but there is a trade-off between ascending slowly enough to avoid wasting propulsive energy on drag, and fast enough to avoid the external heat soaking into the vehicle components.

Mercury

The planet Mercury has remained unvisited by a spacecraft since the fly-by mission of Mariner 10 in 1974/5. The closest planet to the Sun, Mercury has a special place in the physics of the Solar System on account of its high density and its magnetic field. In addition, the massive event that formed the Caloris basin (perhaps a 70 km asteroid with a collision velocity of 50 km/sec [7]) generated temperatures and shock levels unmatched in the Solar System. The Caloris fireball melted the Mercurian landscape in depth from horizon to horizon, and the effects of the shock are visible on the far side of the planet.

NASA has looked at the possibility of a Mercury orbiter mission using a Venus swing-by similar to that of the Mariner 10 probe [8]. The spacecraft would actually be a dual probe – separating as it approached Mercury to give a low level (105 km altitude) orbiter for geophysical mapping, and a high level orbiter in an elliptical orbit to make particle and field measurements on the planet's magnetosphere. While the scientific payloads of the two spacecraft are distinct, the supporting telecommunications, data handling and control, attitude control, thermal control and structure would be common.

Thermal control is likely to be the major problem faced in a Mercury orbiter design. Not only is direct radiation from the Sun more than ten times that at Earth, but reflected thermal radiation from the planet is over twice that from the Sun at the Earth. The spacecraft design favoured by JPL has a long, thin structure with its axis aligned towards the Sun, with "planet shading" wings extending from the sides to protect the thermal radiation surfaces from the reflected glare of the

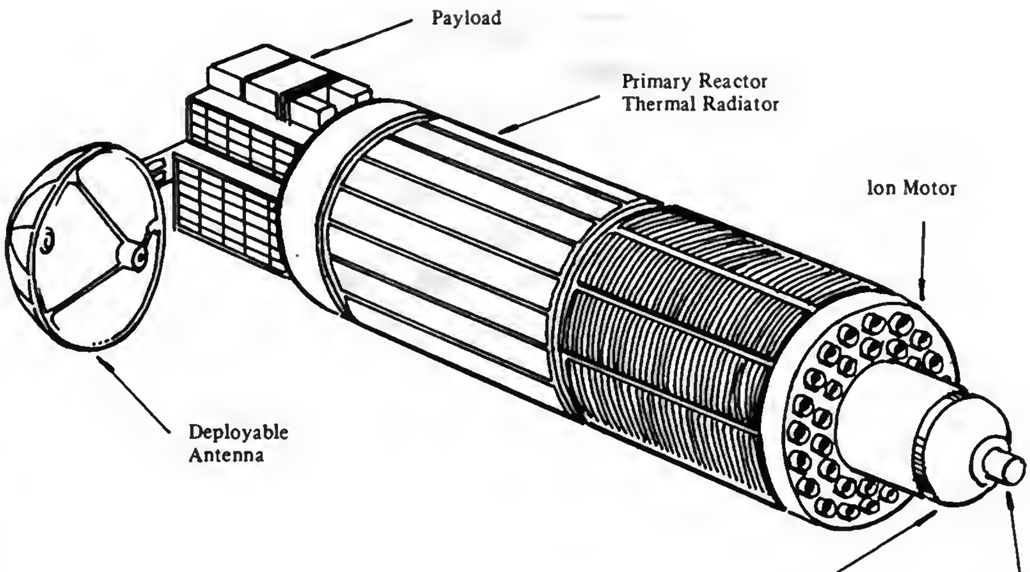


A Ganymede or Europa lander probe might penetrate deep within the rock-and-ice surface using a nuclear isotope-heated probe to melt its way to considerable depths.

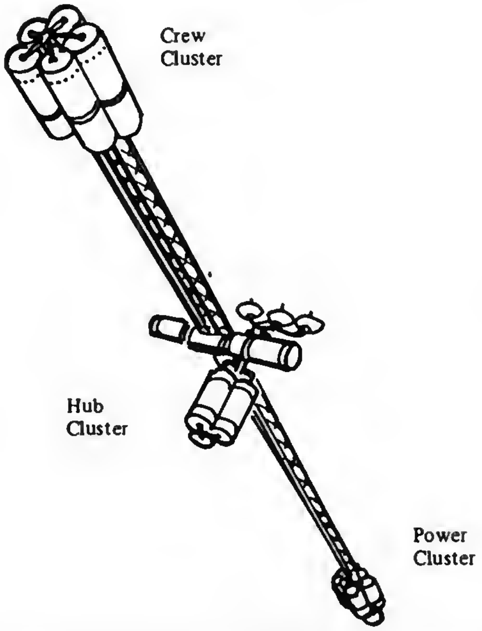
planet. Particular mission opportunities exist for 1986 and 1994 which would be sufficiently favourable to allow a small "rough lander" probe to be included in the mission.

It is perhaps too early to speculate on what might entice us to think of a manned mission to Mercury. There would be similar technical problems to those for unmanned missions in protecting the crew from the near-approach to the Sun, but possibly on a greater scale. Using a Venus swing-by manoeuvre, the delta-V requirement for a round trip to Mercury is about 18 km/s [9], compared with about 12 km/s for a Mars mission. The trip time is, however, significantly shorter. For a 1997 launch the whole mission would take just 421 days, with 136 days in orbit about Mercury. Such stop-over times would allow very considerable exploration of a chosen surface region, and might provide sufficient justification for such a mission early in the 21st Century.

The Mariner 10 trajectory, where the spacecraft made repeated approaches to the planet without orbiting it, even suggests that there might be more economic mission plans where the return vehicle does not enter orbit about Mercury



A 400 kW Nuclear-electric stage being studied by NASA would deliver multi-tonne payloads to Outer Planet targets.



A manned mission to Jupiter might be achieved with chemical propulsion, but it would need nuclear power and artificial gravity for life support on a flight lasting up to five years.

at all, but simply makes rendezvous with the excursion module on a second or subsequent approach.

Jupiter System

Jupiter and its system of satellites represents a particularly attractive target for future planetary exploration. The Galileo mission is intended to drop a "sounder" probe deep into the Jovian atmosphere, and then use the orbiter to patrol the satellite system over an extended period using "gravity assist" to move from one satellite to another.

The Voyager missions revealed the diversity of the inner satellites, and an understanding of their varied structures is now felt to be vital in forming a picture of the early events in the formation of the Solar System. The outer satellites, which lie in orbits highly inclined to the equatorial plane, are thought to be captured asteroids and are as yet unexamined. Not suprisingly, lander missions to the four Galilean satellites are already being studied. One idea which has merit for Europa and Ganymede – the surfaces of which are largely ice – is to carry a nuclear-heated probe which could melt a deep borehole into the surface of these worlds to investigate the sub-structure.

Surface sample return missions from the Jovian satellites have also recieved some attention. Europa is the preferred target [10], with a guarantee of surface ice from which oxygen and hydrogen can be electrolyzed. If only oxygen were recovered – a relatively easy process since the surface temperature of Europa is within the boiling point range of oxygen – and were used with methane fuel transported from Earth for the return propulsion, the launch mass of a Europa surface sample return mission would be reduced by about 4 tonnes. If both hydrogen and oxygen were utilised, the processing plant would increase in size but the Earth launch mass might be reduced by a further 550 kg.

The diversity of the Jovian system makes me wonder whether it might not be an attractive target for a manned mission with a fairly long stay time. The discovery of the intense radiation belts round Jupiter has made people discount such an exploration, but the long flight times from Earth alone would require extensive radiation shielding aboard the vehicle as protection against solar flares, and at least part of the shielding might be provided by water tanks as part of the life support system. Even if manned exploration of the inner system were precluded, the large communication lag with Earth and the relatively small lag within the Jovian system might make it preferable to have the control crew on the spot.

A round-trip mission to Jupiter, not including side-trips to the various satellites, would require a delta-V of 23 km/s and a round-trip time of five to six years – both of these twice those for a Mars mission. However, the fact that water ice is almost certainly available on the outer Galilean satellite of Callisto makes it attractive to contemplate setting up a propellant factory here at the beginning of the stay and using this to provide not only fuel for intra-system visits but for the return leg of the mission itself.

By 1980 standards a manned mission to Jupiter would appear to be a massive undertaking akin to the original von Braun "Marsprojekt" back in 1952, although still more modest in terms of initial mass in orbit. While chemical propulsion might be sufficient to launch and recover the expedition, in-flight power and power for the propellant plant on Callisto would require nuclear systems. The expedition would have to carry a wide range of probes for exploration, and would need multiple redundancy for the recovery of the crew. Almost certainly for such extended flight times it would need "artificial gravity" for the crew's health, and one can imagine a small fleet of vehicles carrying different segments of the mission during the propulsive phases which cluser together into one "sling-shot" configuration for periods of cruise.

Conclusion

The plans outlined in this article are deliberately speculative. They belong not to the immediate future but to the opening of the twenty-first century. Everything could be transformed by breakthroughs in critical areas – by the development of a nuclear-fusion or gas-core fission propulsion system, or high level artificial intelligences for example. But developments in space are most likely to be driven by events in Earth orbit directed at exploitation rather than exploration. Such developments could call for large space systems which would mean that missions on the scale discussed here would become relatively easy affairs – just as the oceanic explorations of the seventeenth and eighteenth centuries used available, second-hand ships.

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STS-2: A MISSION ALMOST ACCOMPLISHED

Introduction

The Shuttle's second mission can be regarded as the flight that brought us back to Earth with a bump after the euphoria of STS-1 a year ago. Although as a whole it was successful, the problems which caused the launch delays and the early return from orbit show that the system is still not at operational status. Add on to that the fact that processing between missions is still taking months, rather than weeks, and we have a picture of the Shuttle which may drive more commercial customers back to expendable launch vehicles.

Following Young and Crippen's flight last April, STS-2 was scheduled to go into orbit in late September but a number of delays - the most dramatic arising from the propellant spillage on 22 September - pushed the date into early November. It is exactly this kind of problem that has to be overcome if the Shuttle is to become a regular, reliable stepping-stone into space.

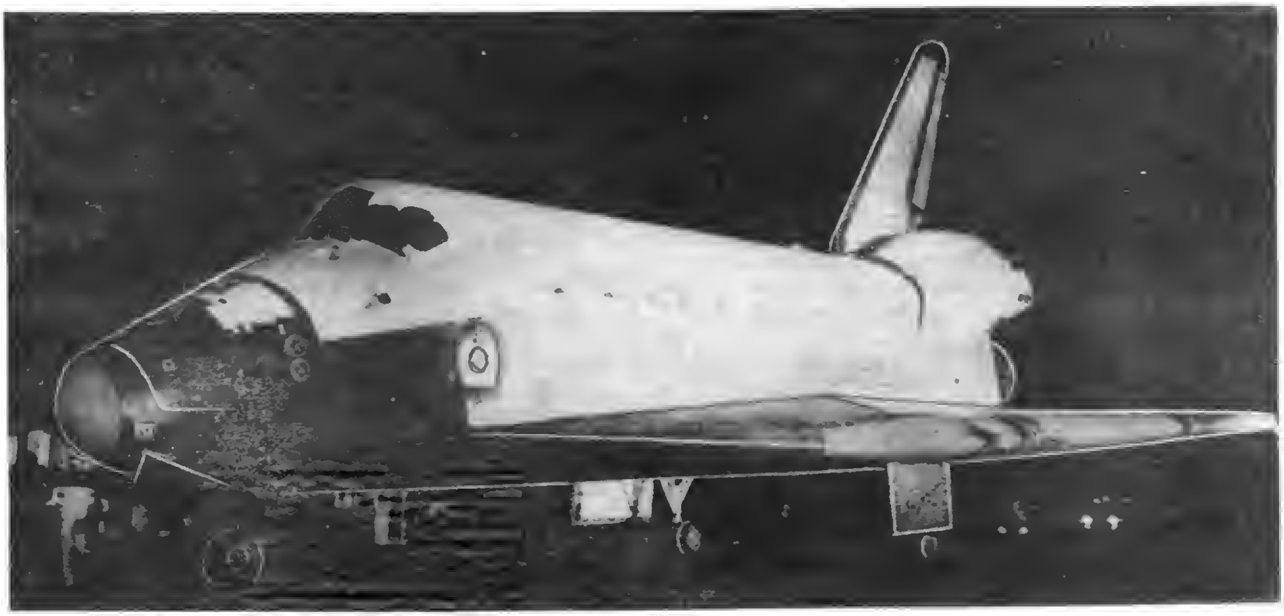
But having said that, STS-2 can be viewed as an overall success, with many of the secondary objectives being achieved. Although this flight was certain to attract less attention than the first (similar to Apollo 12 after the first Moon landing), about a quarter of a million people turned up in the Cape area to witness the second launch attempt. That figure will no doubt drop off for the next few flights but the first time that an Orbiter lands back at the Kennedy Space Center (planned for mission 5) we should see large crowds once more.

Launch

The first attempt on 4 November to leave Pad 39A failed to overcome several problems and NASA officials decided to order a postponement, although subsequent analysis suggested that a launch was possible. The first worry was the weather. For several days the area was under heavy cloud cover and the mission rules stated that it had to be 50% or less (to allow photography and visual observations during the launch). John Young flew around to check the conditions and declared them to be tolerable. Wind speed was quite low, an important factor since the vehicle clears the launch tower by a matter of feet. A large gust at the wrong time and the two could have come

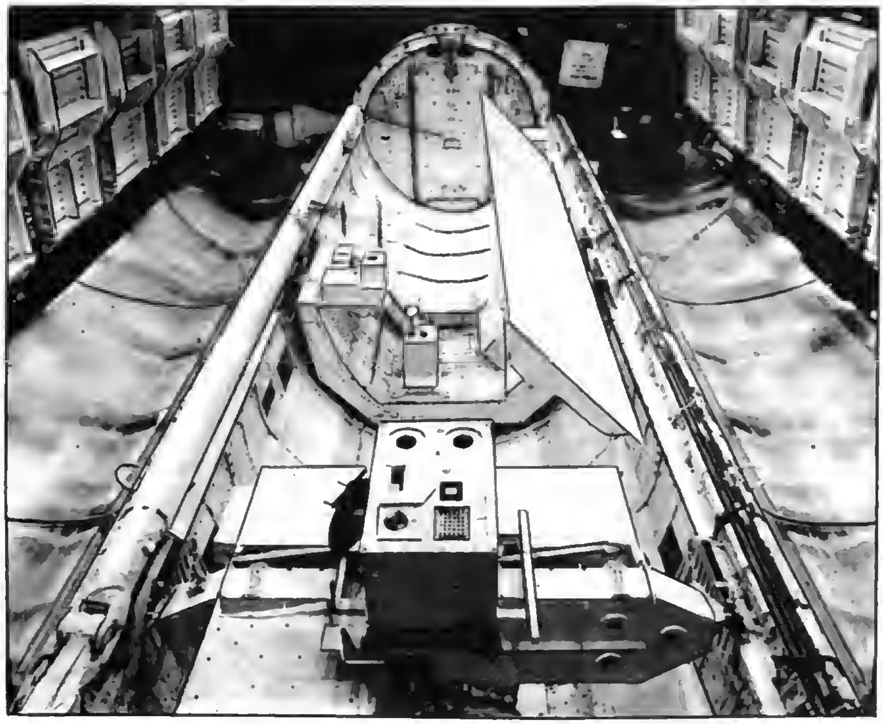
STS-2 CHRONOLOGY

22 Apr	External Tank for STS-2 arrives at KSC.
22 Apr	Remote Manipulator Arm arrives at KSC.
28 Apr	*Columbia* returns to KSC on the back of its 747 carrier aircraft.
29 Apr	*Columbia* is back inside the Orbiter processsing facility at KSC.
11 May	Launch platform is moved into VAB.
15 May	NASA announces the target launch date is 30 September.
20 May	Stacking of SRB segments on Mobile Launcher Platform 1 in the VAB begins. Completed 2 June.
30 Jun	External Tank mated with stacked boosters.
1 Jul	OSTA-1, the experiments payload, is inserted into the cargo bay.
27 Jul	Test with Engle and Truly in cockpit, with power systems for OSTA-1 and the remote manipulator turned on. The integrated tests are completed on 29th.
10 Aug	*Columbia* is transferred to the VAB ready for mating with the External Tank and Boosters (completed 12 Aug).
31 Aug	The vehicle is transported to Pad 39A.
15 Sep	Test loading of External Tank completed.
22 Sep	Oxidizer spill damages 379 tiles. Final tile replaced 13 Oct. Launch delay.
8 Oct	Launch rescheduled to 4 November.
22 Oct	Loading of hypergolic propellants completed.
4 Nov	Launch postponed at T-31s.
12 Nov	Launch!
14 Nov	Landing at Edwards AFB.



Columbia is towed towards the Vehicle Assembly Building from its Processing Facility on 10 August for mating with its boosters and External Tank.

NASA



Columbia's cargo bay for STS-2 (see separate listing of experiments), looking forward towards the crew compartment. In the foreground is the Induced Environment Contamination Monitor, with the Earth resources Spacelab pallet behind. The Remote Manipulator arm can be seen at left. The shortened mission meant that some data were lost but NASA expressed satisfaction at the results: 8 hours of data from the Imaging Radar (SIR-A), 108 minutes of cloud free observations with the Infrared Radiometer (SMIRR); 32 hours of Air Pollution (MAPS) data, 78 minutes of cloud-free ocean observations (OCE); 32 hours of Feature Identification (FILE) data. Crew observations of storms (NOSL) were severely curtailed and the Sunflower growth experiment was not completed.

NASA

into contact. The launch window extended for 4 hours 40 minutes but there was a 1 hour 50 minute "hole" to prevent the Sun shining directly into the astronauts' eyes during landing.

The 73 hour countdown began on 31 October and proceeded smoothly but the planned hold at T-9 minutes (the beginning of the computer-controlled automatic sequence) lasted longer than expected because pressure in the oxygen section of the External Tank was low. The countdown continued without a hitch until the computer commanded a hold at T-31 seconds because the oxygen tanks feeding the fuel cells were below pressure. The engineers on the spot decided that the readings were acceptable but they failed to override the sequencer in time (shades of the late hold during the Apollo 17 launch).

While that difficulty was being overcome, it was noticed that the oil pressures (100 instead of 60 psi) in the Auxiliary Power Units were not normal. The countdown had been recycled to T-9 minutes and then 20 minutes, with the weather conditions becoming worse all the time. A postponement was called to allow the mystery of the high APU pressures to be solved. The fear was that contamination in the oil would clog filters and prevent the vital lubrication/cooling action from taking place. It was significant that the high pressures were seen in units 1 and 3, which had been left as they were (apart from refuelling) after STS-1, and not unit 2, which was a replacement for a APU that failed on the first mission.

By the time Engle and Truly emerged from *Columbia* they had been aboard for 5 hours, close to the 6 hour limit set by doctors.

The auxiliary power unit (APU) is a hydrazine-fuelled turbine-driven power unit which generates the mechanical shaft power to a pump that produces pressure for the Orbiter's hydraulic system. Three separate APU's, hydraulic pumps and hydraulic systems, are all located in the section behind the aft bulkhead.

The APU's and their fuel systems are isolated from each other so that a single system failure will not affect full operational performance. If two systems fail, the third system will provide sufficient hydraulic power, but at a reduced rate.

The three APU's/hydraulic pumps operate during launch to provide the three main engines with propellant valve control, thrust vector control (by hydraulically gimbaling the three main engines) and control of the Orbiter hydraulic actuators.

The APU's and pumps are restarted prior to deorbit and operate continuously for hydraulic positioning of Orbiter aerosurfaces (elevons, rudder/speedbrake, body flap) during the

[Continued on page 107

STS-2 EXPERIMENTS

OSTA-1 carried five groups of experiments on a British Aerospace-built Spacelab pallet. These were:

Shuttle Imaging Radar-A (SIR-A) - to test geological mapping using radar.
Shuttle Multispectral Infrared Radiometer (SMIRR) - to test remote sensing in 10 IR bands.
Feature Identification and Location Experiment (FILE) - to test a system for automatically sorting remote sensing images.
Measurement of Air Pollution from Satellites (MAPS) - to test the measurement of carbon monoxide in the lower atmosphere.
Ocean Colour Experiment (OCE) - to test a method for following fish schools.

Two experiments carried in the crew compartment, were:

Night/Day Optical Survey of Lightning (NOSL) - astronauts photographed lightning and storms to provide data for early predictions of severe storms.
Heflex Bioengineering Test (HBT) - 72 plant modules carried in small containers with Sunflower seeds, to investigate effects of weightlessness.

Other experiments carried were:

Induced Environment Contamination Monitor (IECM) - to measure induced pollution around the spacecraft.
Aerodynamic Coefficient Identification Package - to measure and record aerodynamic data. Recorder failure lost some of data.

A test panel with 11 tiles of different sizes and spacing was attached underneath the Orbiter. An iron-cobalt-chromite-spinel coating was added to two other tiles to see if it improved the thermal qualities. The Kuiper Airborne Observatory was to take infrared pictures of the Shuttle during reentry in order to obtain temperature data (failed).

THE ASTRONAUTS

Crew for the Shuttle's second mission, 12-14 November 1981: Joe Engle (left) and Dick Truly. Backup crew was Tom Mattingly (ex-Apollo 16) and Henry Hartsfield.
NASA

Joe Henry Engle

The third man to ride a Space Shuttle into orbit was also the third man to fly a Shuttle during the Approach and Landing Test (ALT) Programme of 1977. Before joining NASA in 1966 Engle had already gained his space 'wings' during three flights in the X-15 programme.

Air Force Colonel Joe H. Engle was born on 26 August 1932 in Abilene, Kansas, and was educated in primary and secondary schools in Chapman, Kansas, finally graduating from the Dickinson County High School. He entered the University of Kansas and graduated with a Bachelor of Science Degree in Aeronautical Engineering in 1955.

Engle has had a very colourful flying career, culminating with his epic orbital flight in *Columbia*. Commissioned in the USAF through the AFROTC Program at the University of Kansas, he entered flying school in 1957, and went on to assignments with the 474th Fighter Day Squadron, and then the 309th Tactical Fighter Squadron at George AFB, Calif. His next assignments took him abroad to Spain, Italy and Denmark, before returning to the United States to enter the USAF Experimental Test Pilot School. Upon graduation in 1961 he was named, on 22 October 1962, as a Class 3 Astronaut Designee for the USAF eight month astronautical course at the Aerospace Research Pilots School. Graduating in June 1963, he was assigned as test pilot in the Fighter Test Group at Edwards AFB, and later the same month it was announced that he had been selected for the X-15 programme at Edwards. For the next three years he took an active part in the historic X-15 series, flying a total of 16 missions in crafts 1 and 3. Three of these flights broke the 50 mile altitude level to qualify Engle for his astronaut rating. He attained his greatest height of 280,600 ft on 29 June 1965 during his 13th mission.

Engle was selected for the NASA programme on 5 April 1966 as one of 19 Group 5 Pilot Astronauts. After the initial academic and practical training he was assigned to the Apollo programme. His record is as follows: in 1968 served as crew member on the eight day space simulation test of CSM 2TV-1 with astronauts Kerwin and Brand in preparation for Apollo 7; named Support crew member for Apollo 10, 13 November 1968, serving as a shift CapCom during mission in May 1969; named backup LMP Apollo 14 5 August 1969, trained for and supported mission during 1970 through February 1971; original LMP for Apollo 17, replaced by geologist astronaut Jack Schmitt and lost the chance of becoming the 12th Man to walk on the Moon. When Apollo 17 did fly in December 1972 Engle was involved in the early stages of the Shuttle development (ALT Mission Phase; controls and displays-hardware); named Commander of second crew for ALT programme 24 February 1976, flying second Captive/active flight on 28 June, the second free flight on 13 September 1977 and finally the fourth on 12 October; named Commander of second Shuttle OFT crew 17 March 1978, and backup Commander STS-1; served in backup STS-1 capacity through April 1981, subsequently confirmed Commander STS-2 in April 1981. He became the 45th American and 104th person to fly in space. He was also the second former X-15 pilot to orbit the Earth some 15½ years after Neil Armstrong in Gemini 8.

Engle is married with two children.

Richard Harrison Truly

Commander Richard H. Truly of the US Navy was the Pilot of STS-2. Born on 12 November 1937 in Fayette, Mississippi, he attended schools in Fayette and Meridian, Mississippi, and subsequently entered the Georgia Institute of Technology (as did STS-1 Cdr John Young), graduating with a Bachelor of Aeronautical Engineering degree in 1959. An NROTC graduate, he was commissioned in the US Navy and completed flight training in 1960 in Beeville Texas. From 1960-1963 he was assigned to Fighter Squadron 33, and during same period served aboard the *USS INTREPID* and the *USS ENTERPRISE* and accumulated over 300 carrier landings. He then enrolled as a member of Class 64A at the USAF Aerospace Research Pilot School, Edwards Air Force Base, Calif, and following graduation was assigned as an instructor there. On 12 November 1965 he was selected as one of eight Group 1 astronauts for the USAF MOL programme, serving in the capacity of flight crew member from November 1965-June 1969 when the programme was cancelled before a manned flight had occurred. He transferred to NASA on 14 August 1969 as one of seven Group 7 former MOL astronauts. Reporting for duty in September 1969, Truly completed the basic training evaluation programme before assignments in the Skylab programme in January 1972; served as astronaut support crew member and CapCom for all three Skylab missions May 1973-February 1974; selected for support crew ASTP 30 January 1973, serving in dual role as support crew for Skylab and ASTP through February 1974 when he turned his full attention to ASTP. Also served as CapCom during ASTP mission July 1975; 24 February 1976 named Pilot second ALT crew flying second Captive/active flight on June 28, and the second and fourth free flights on 13 September and 12 October 1977 respectively; named Pilot second OFT crew and Backup STS 1 Pilot 17 March 1978, serving as backup STS-1 Pilot through April 1981 before being confirmed as Pilot for STS-2. Truly was the 46th American, and the 105th person, to fly in space. Married with three children, he is the second Group 7 astronaut to achieve orbital flight (the first being Crippen).

D. J. SHAYLER

Above: *Columbia* in the Orbiter Processing Facility in August. *Below*: transfer to the pad on 31 August. *NASA*

COUNTDOWN MAIN EVENTS

T-20 h	Retract Rotating Service Structure.
T-10 h	Sound suppression water tank fill.
T-7 h	Begin clearing pad for countdown. Clearing complete by T-5 h.
T-5 h	Begin final countdown. Begin chilldown and fill of External Tank.
T-3 h 30 m	Wake up flight crew for breakfast and suiting.
T-2 h 5 m	External tank filled, in top-off mode.
T-2 h 5 m	Enter 1 h built-in hold. Crew starts move to pad during hold.
T-1 h 50 m	Crew entry and hatch closeout begins. Complete by T-1 h 5 m.
T-30 m	White room crew clears pad.
T-20 m	Enter 10 m built-in hold.
T-9 m	Enter 10 m built-in hold.
T-9 m	Launch Director "go-for-launch" received. Start ground launch sequencer (auto sequence).
T-7 m	Retract crew access arm.
T-5 m	Start Orbiter auxiliary power units. Arm External Tank/Solid Rocket Boosters ignition and range safety systems.
T-3 m 30 s	Orbiter transfers to internal power.
T-2 m 55 s	Begin pressurization of liquid oxygen tank; retract vent hood (beanie cap) and arm.
T-1 m 57 s	Begin pressurization of liquid hydrogen tank.
T-28 s	Solid rocket booster hydraulic power units activated. Orbiter computers assume control of terminal countdown.
T-7 s	Main engine start sequence.
T-3 s	Main engines at 90 percent thrust.
T-0	Solid rocket booster ignition and hold-down post release. Liftoff.

Continued from page 104]

atmospheric flight portion of entry and to provide hydraulics for nose and main gear deployment, nose gear wheel steering and main landing gear braking.

The systems are not used in orbit, except possibly for checkout.

Each system supplies fuel to its respective fuel pump and control valves, then to the gas generator where catalytic action decomposes the fuel and the resultant hot gas drives the APU two-stage turbine. The turbine assembly provides mechanical power to the gearbox which drives the fuel pump, hydraulic pump and oil lube pump. The APU lube oil system is circulated through a lube oil heat exchanger in the APU/hydraulic water spray boiler to cool the lube oil system.

The turbine exhaust of each APU flows over the exterior of the gas generator exterior to cool it and is then directed overboard through an exhaust duct at the upper portion of the aft fuselage near the vertical stabiliser.

Oil samples were taken and analysis showed that the contaminants – caused by some of the hydrazine fuel leaking through and reacting with the oil – would have probably dissolved back into the oil as the units warmed up. In future, NASA will change the lubricant between flights.

The second launch attempt on 12 November faced difficulties of its own. A hold at T-8 hours stretched beyond 13 hours after a multiplexer/demultiplexer aboard *Columbia* failed. This is a unit involved in processing data from sensors spread around the craft for transmission to the ground. Unfortunately, a spare kept at the Cape failed to work after installation and a unit from *Challenger*, the Shuttle then still under construction in California, had to be flown in. It arrived in the early hours (GMT) of launch day and was rushed straight to the waiting ship.

The flight unit for Spacelab 1, intended for launch in September 1983, was handed over to NASA on 4 Decmber in a ceremony at Bremen.

Otherwise, the count proceeded smoothly and the hold at T-9 minutes was extended in order to check everything was running as it should. The flight controllers wanted no more last-second stoppages.

Columbia, weighing 4,474,269 lb, left Pad 39A for the second time at 15.09.59.887 GMT on 14 November – Dick Truly's 44th birthday – with the three main engines and two solid boosters burning well. Seven seconds later, observers could see the vehicle go through a 118 degree roll to take it onto the correct heading as it arced out over the Atlantic on its way to orbit.

The dangerous pressure pulse recorded during the STS-1 booster ignition on the pad was reduced to an acceptible value on this occasion by spraying water into the rocket exhausts and suspending troughs of water below the craft.

Tracking showed that *Columbia* was climbing more steeply than it should have done – a factor affecting the amount of payload that the Shuttle can carry – at about the same rate as STS-1.

The solid boosters separated at T+2 minutes 10 seconds and the main engines continued to burn until shutdown at 8 minutes 42 seconds when the vehicle was about 60 nm high. The SRB recovery teams had to brave rough seas and the boosters spent longer at sea than the STS-1 pair. Inspection showed there to be about half as much damage as on the first flight, with the main damage being caused by the nozzle extensions failing to separate before impact. The External Tank jettisoned a few seconds after main engine shutdown, leaving it to tumble slowly (the tumbling mechanism failed on STS-1) down into the Indian Ocean 256 seconds later.

Finally, a 1½ minute burn with the OMS engines pushed *Columbia* into orbit at a speed of 25,667 fps, just 1 fps short of target.

In Orbit

The first signs of serious trouble arose 2½ hours after lift-off when the crew reported an increase in the alkaline level of the electrolyte in the number 1 fuel cell. The three cells carried by *Columbia* provide the entire craft with power and supplement the crews' drinking water supply as a by-product, so any problems with the cells are treated very carefully. Fuel cells have been carried in manned spacecraft since Gemini 5 in 1965 but they have a reputation for being temperamental (as indeed they were in that first mission).

Each of the Orbiter cells weigh about 200 lb and sit at the bottom of the cargo bay just behind the pressurised crew compartment. They produce between 2 and 12 kW of power, with any one of them sufficient to run *Columbia* safely. On this test flight, however, the mission rules were that if only two cells were available then the flight had to be ended short of the planned 124 hours. A series of complicated manoeuvres to gather aerodynamic information during reentry was one of the prime objectives and if a second cell had failed these manoeuvres would have had to be cancelled.

Each cell's power section ("cell stack") contains two parallel substacks, which have 32 cells in series. The cells contain electrolyte consisting of potassium hydroxide and water, an oxygen electrode (cathode), and a hydrogen electrode (anode).

The hydrogen and oxygen reactants enter each power plant and pass through preheaters for warming from cryogenic temperatures to 40°F or greater. They then pass through filters and into a two-stage integrated dual gas regulator module.

Hydrogen is routed to the cell's hydrogen electrode, where it reacts with hydroxyl ions in the electrolyte. This electrochemical reaction produces electrons (electrical power), water and heat. Oxygen is routed to the cell's oxygen electrode, where it reacts with the water and returning electrons to product hydroxyl ions. The hydroxyl ions then migrate to the hydrogen electrode, where they enter into the hydrogen reaction at that electrode.

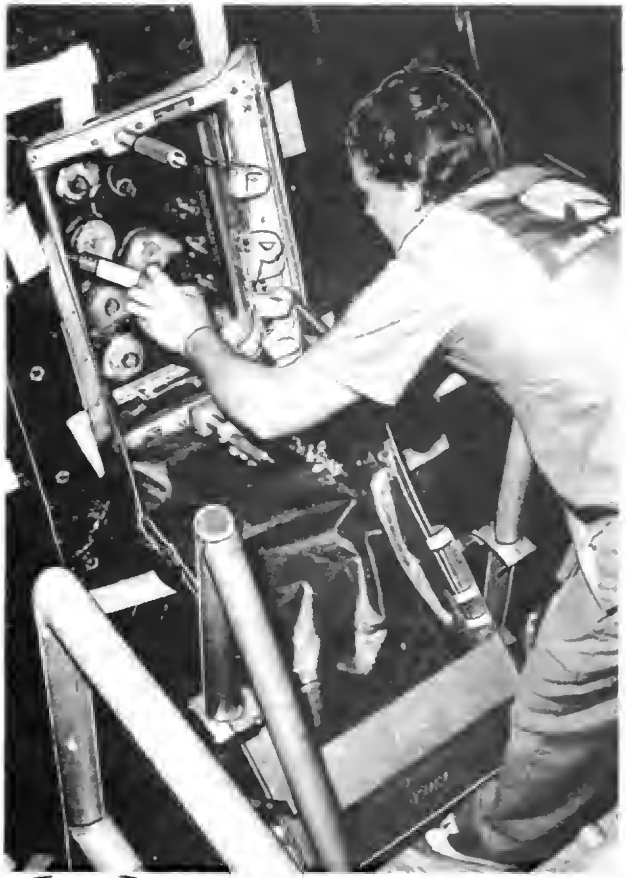
Hydrogen and water vapour from the reactants leave the cell stack, mix with replenishing hydrogen from the storage and distribution system, and enter a condenser, where waste heat is transferred to the fuel cell coolant system. The resultant temperature decrease condenses some of the water vapour to droplets and a centrifugal separator extracts the liquid water and pressure-feeds it to tanks in the lower deck of the crew cabin. From here it can be used for crew consumption and cooling of the Freon-21 coolant loops. The remaining circulating hydrogen is directed back to the fuel cell stack.

All three cells, designed to last for up to 1,000 hours of operations, had already seen extensive service in the three captive and five free-flight tests of *Enterprise* in 1977, accumulating some 212 hours of operation. The two cells used during Young and Crippen's mission were removed for modifications – although they had behaved well – and replaced by the old units after acceptance tests.

Will NASA ever attain its advertised two-week turnaround for operational Shuttles? One agency official told press gathered for Columbia's second mission that it took 700 workdays to prepare STS-1, about 150 days for STS-2 and will require 93 days for STS-3. Donald K. Slayton, astronaut spokesman, suggested the planned goal might be reached by the 15th mission – or 1985. But Michael Weeks, acting Shuttle programme chief, suggested that at best 10 flights per year can be expected of each vehicle in a four-Shuttle fleet.

This decision has led to some criticism but, after all, one of the Shuttle's prime objectives is to be *reusable* so reflying old units is not unusual.

The worry with cell 1 was that some of the excess water being produced might have separated into an explosive mixture



A technician installs a "bib" underneath the hypergolic servicing panel to protect the tiles from propellant spillages such as occurred on 22 September.

NASA

of hydrogen and oxygen gases, or that the electrolyte might have leaked through to contaminate the crew's drinking water. Mission controllers therefore decided to close the unit down and rely on the other two but, instead of chopping the flight back to 54 hours, they continued to aim for the full duration. Flight Director Neil Hutchison told pressmen gathered in Houston that evening they would continually assess how the mission was going, hoping to gradually extend it to the planned 124 hours. This news was not entirely unexpected because any early curtailment would have brought unjustified bad publicity at a time when the space programme was already suffering severe cutbacks.

But caution won over and it was decided to bring *Columbia* back early after all. Capcom Sally Ride - a Mission Specialist astronaut who will probably fly on one of the early missions - radioed up to Engle and Truly barely a day after achieving orbit: "Columbia, this is Houston. We have some bad news for you. You're going to be coming home tomorrow." Engle responded, "Oh boy, that's not so good."

Reducing STS-2 to 2 days was not an indication of a failed mission because the experiments had been deliberately planned with the most important sections coming early in the expected 84 revolutions. For example, 12 hours of testing the Remote Manipulator had been spread over three days, with the first session containing the more important exercises. In the end, Engle and Truly managed only a 4 hour work-out but they demonstrated the basic reliability of the system.

The first major action in orbit was to open the cargo bay doors and deploy the radiators which rid *Columbia* of its waste heat. The flight plan showed the opening taking place less than 1½ hours into the mission but Engle and Truly had trouble using the theodolite which detects any distortion in the structure. The crew had to be sure they could close the doors but they delayed for about half an hour while they struggled to see the theodolite targets in the dark cargo bay.

Tests of the Remote Manipulator, although severely curtailed, showed that the robot arm could operate in space. The most important sequences were deliberately planned to fall within the first day's operations so, although only one-third of the intended time was devoted to arm manipulation, NASA and Canadian planners could go ahead with some confidence on forming more ambitious plans for STS-3.

Truly began unstowing operations about 22 hours after launch, taking the arm out of its cradle down the port side of the cargo bay. He tested the two modes of operation - manual, and the automatic sequence in which the operator punches in the target location and the Orbiter General Purpose Computer

The starboard OMS pod being removed after the first mission last April. Note the protective plugs in the thrusters.

NASA

moves the arm – and found them to be smooth. In fact, he said the motion was smoother than during the ground simulations.

Firing *Columbia's* main RCS thrusters provided information on how the arm behaved under craft acceleration.

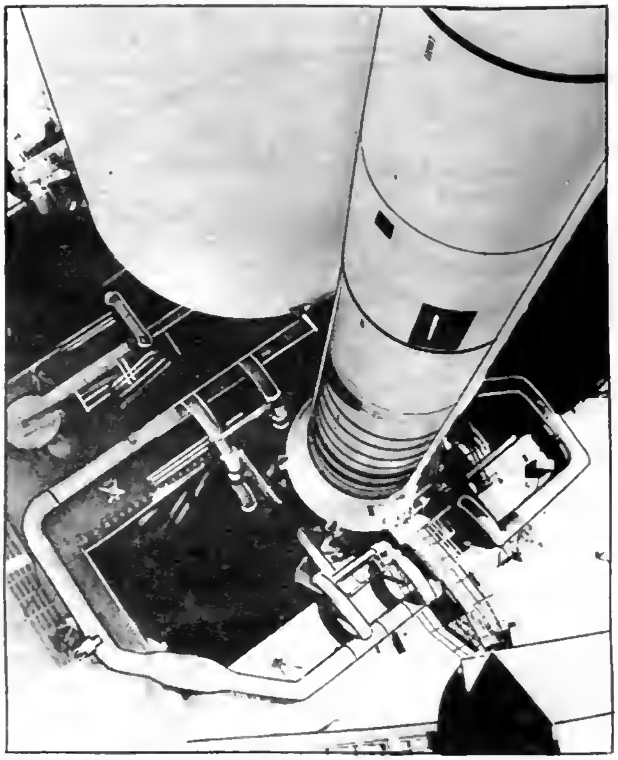
Viewers on the ground were able to see the Orbiter from some unusual positions. So far, we have seen through TV cameras mounted in the crew's cabin or the cargo bay but the Manipulator carries two cameras at the elbow and wrist joints and these were directed towards the astronauts from above and behind as they stood at the rear facing windows. Truly responded by holding a sign up bearing the words "Hi, Mom", rather reminiscent of the Apollo 7 crew's "Keep those cards and letters coming in folks" some 13 years before. These cameras promise exciting pictures when the arm is actually used for deploying and retrieving satellites.

As the arm was being stowed back in its cradle, a back-up drive mode (in which the three joints are moved one at a time) failed and Truly had to go back to a primary mode. The TV cameras also failed after an electrical fault, but neither problem was considered to be major.

Back to Earth

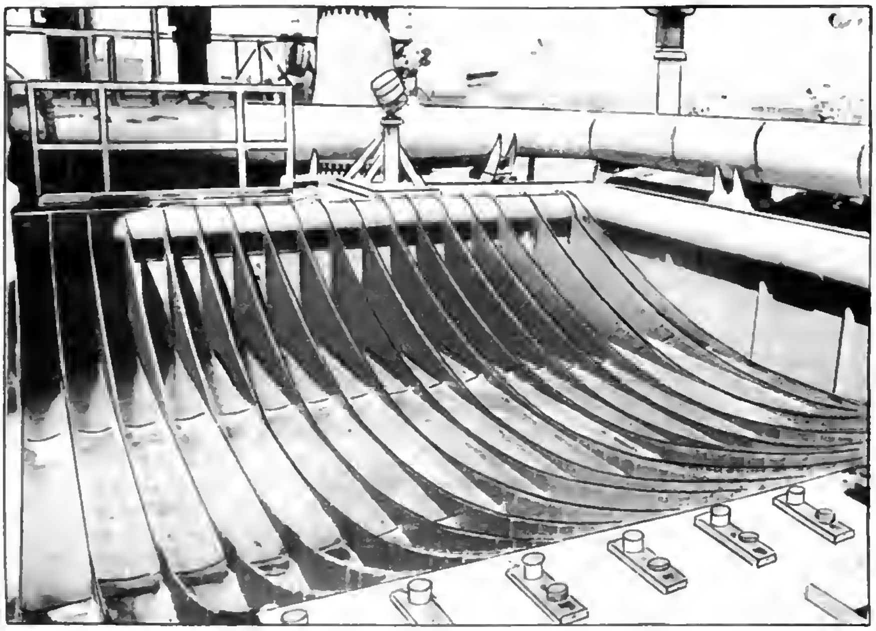
The reentry of *Columbia* was perhaps the most important part of the whole mission since Engle and Truly planned to execute no less than 19 groups of manoeuvres designed to extend our knowledge of the aerodynamic qualities of the craft. Planners expected that there might not have been enough time to perform them all but they were all achieved – an accomplishment tempered somewhat by the discovery that a flight recorder (some were carried out during radio blackout so no telemetry could be transmitted to ground recorders) had failed and some of the data was lost.

An hour before the deorbit burn over the Pacific Ocean, the two astronauts were advised to land on Runway 15 at Edwards after John Young had tested the landing conditions and found them to be suitable for a touchdown with the wind blowing across their path. This is an important requirement for qualifying the craft to land on the strip at KSC. But Young later found the winds to be close to the tolerance limit and a switch was made back to Runway 23 for a landing into the wind. These different approaches were already plotted in *Columbia's* computers and it was a relatively simple procedure to switch from one to the other.

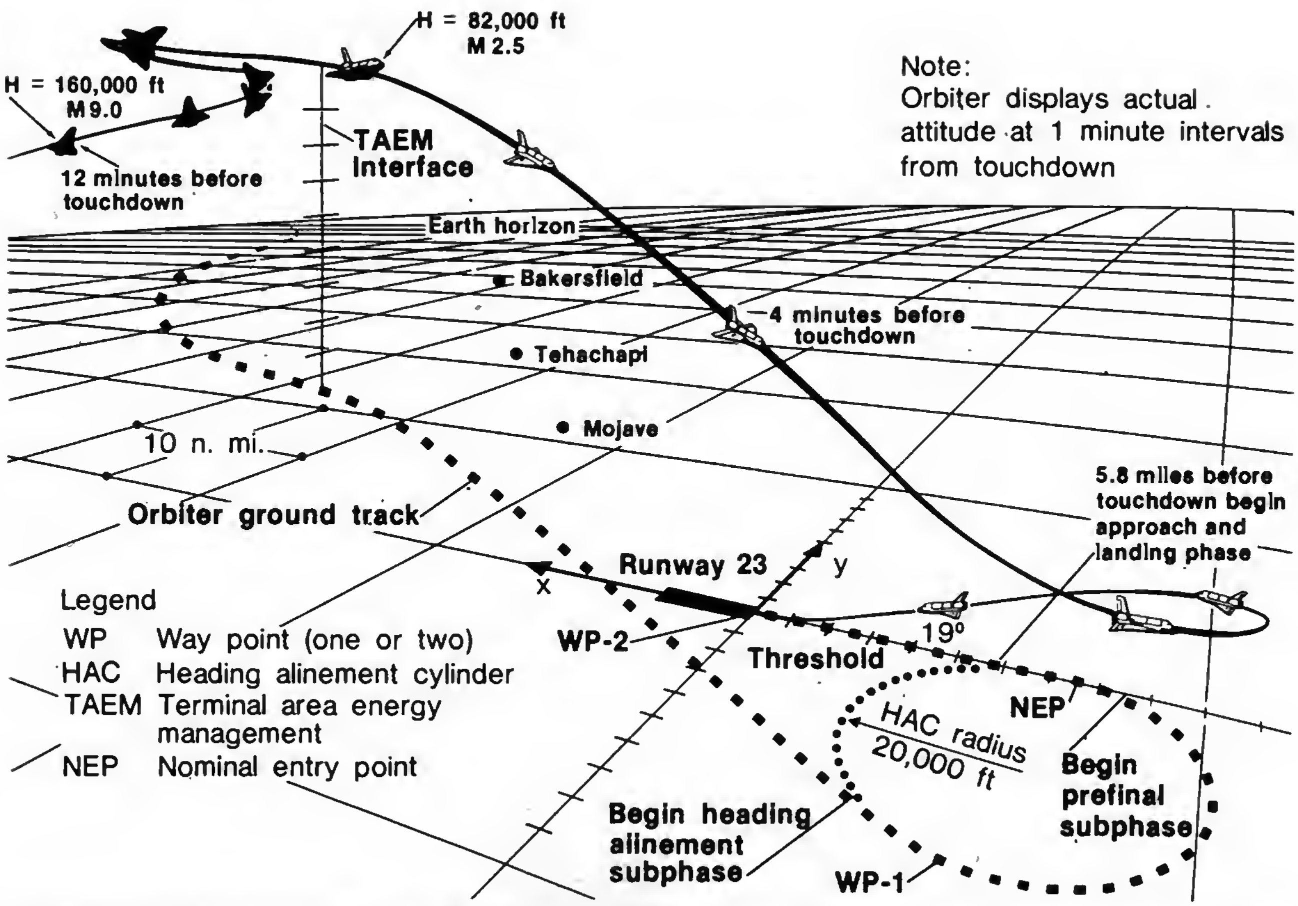


One of the exhaust ducks for the Solid Rocket Boosters. The water spray system was modified to reduce the pressure pulse arising from booster ignition (see picture below).
NASA

Fuel was earlier dumped from the RCS and OMS systems to shift the centre of gravity further aft and a further 1300 lb was consumed in a 2 minute, 55 second burn by the 6,000 lbf OMS engines in chopping 313 fps off the orbital velocity in order to bring the orbit within the atmosphere. *Columbia* swept up over the Pacific Ocean with both the automatic systems and the astronauts executing the data-gathering manoeuvres as they slowed down from Mach 25. The craft drifted 25 miles south of, and 3,000 ft below, the planned path but



Water troughs below the boosters were used to reduce the ignition pressure pulse from the 2 lb/in² experienced during the STS-1 launch, to the design value of 0.5.
NASA



Nominal STS-2 entry and landing profile. Engle cut inside the HAC (Heading Alignment Cylinder) to keep the acceleration below 2g on John Young's advice.

was gradually brought back onto the correct heading. Engle took over control as *Columbia* began its turn to sweep around the 20,000 ft diameter Heading Alignment Cylinder 40,000 ft high (see landing diagram) to head back towards Runway 23. He actually cut inside the intended arc in order to keep the acceleration below 2g (the original plan was to fly around the HAC automatically but John Young found that the wind speed might have been too high).

The new Autoland system took over at 18,000 ft, using data from the MSBLS (Microwave Scanning Beam Landing System) to bring the craft down to 2,000 ft. As it came into play, it ordered a slight upward angle to bring the flight path back up to its correct altitude. Engle took over at 2,000 ft and flared the path out to a landing at about 195 knots, slightly short of the target but acceptable because of the strong headwinds.

The first of the servicing vehicles was in position 5 minutes later, with ground crews searching the area for dangerous gases and liquids. Initial inspection of the tiles showed there to be much less damage than after the first flight, with perhaps the number needing replacement in the low tens. One surprise was that two new types of damage were found: some tiles had their upper surfaces torn away, and blistering occured near the body flap at *Columbia's* rear.

STS-3 and After

Commander of the 7-day third Shuttle flight will be Jack Lousma who last went into space in the second Skylab mission in 1973. His pilot will be Gordon Fullerton who will thus become the third member (the first two being Crippen and Truly) of the Group 7 ex-Manned Orbiting Laboratory astronauts to fly.

The crewing policy is clearly one of combining an experienced man with a later astronaut. Engle was commander on his first mission but he was, nonetheless, one of the best men available. The Group 7 men (transfered to NASA in 1969) will command their own missions later – the first being Crippen – with, probably, some of the new Group 8 pilots under their command.

STS-1	Young/Crippen	(Groups 2/7)
STS-2	Engle/Truly	(Groups 5/7)
STS-3	Lousma/Fullerton	(Groups 5/7)

The first four flight crews announced in April 1978 allocated astronauts Haise/Lousma and Brand/Fullerton to the third and fourth missions, respectively. Haise left NASA in June 1979, leaving Lousma to take over the commander's seat for that flight.

STS-5 will also carry two mission specialists, making it the first four-man spacecraft.

The prime objective of the third test flight, like its two predecessors, is simply to "get-up-there-and-back-down-safely." The planned seven days in orbit is the maximum that the basic Shuttle can handle (a contingency day allows a change in landing if, for example, weather is bad) and if the landing at Edwards AFB goes well the fourth mission may be given the all-clear to try for touchdown at the Kennedy Space Center.

STS-3 will see the Remote Manipulator used in a more adventurous way than on STS-2, with the 360 kg Induced Environment Contamination Monitor (see p. 60 of December's *Space Education*) being picked up and moved around the exterior of *Columbia* in a 2½ hour exercise to see how much

pollution the craft carries around with it in orbit. This is an important measurement because some payloads, such as Spacelab, may have their experiments affected by the local environment.

Lengthy Sun-pointing exercises in various altitudes will show how well an Orbiter can cope with uneven temperature distributions over its skin. *Columbia's* nose will be pointed towards the Sun for some 80 hours, then its tail for another 30 hours, and finally the cargo bay will face the heat for 26 hours. Lousma and Fullerton will see how quickly they can close the cargo bay doors in these positions, an exercise which will prove invaluable should a crew ever need to return to Earth in a hurry.

The "Get-Away Specials" - small, self-contained payloads - have received a good deal of publicity and STS-3 will carry a test version to make measurements of the stresses and strains they will have to undergo (acceleration, temperature, vibration, etc.) About 250 reservations for these small payloads - the minimum size is 0.135 m³ and 90 kg at a cost of $3,000 - had been received at the time of the second mission.

Another STS-3 experiment will study the effects of gravity on lignin (a woody substance which provides plants with their structural stability) formation in plants. By watching how seedlings grow in the microgravity environment of space, scientists expect to learn more about lignin synthesis and how wood is formed. They believe that the plants will grow upward in response to the attraction of the growth unit's artificial sunlight, despite a lack of gravity. But as roots are less responsive to light, scientists are unsure how the roots will grow.

The experiment will take place in a breadbin-sized Plant Growth Unit containing six 25 cm high Plant Growth Chambers which resemble thin, rectangular terrariums.

The six receptacles, built from aluminium and a special heat-resistant polycarbonate material, will house two rows of eight seeds each, in sandwiches of moist sponge and filter paper. There will be oat and bean seeds, and pine seedlings which have already been germinated (pine sprouts take more time to germinate than the Shuttle mission will provide).

During the Shuttle's seven-day sojourn in Earth orbit, the six chambers will receive 14 hours of artificial sunlight from lamps each day.

When the Shuttle lands the sprouts will be taken for examination immediately possibly even before the astronauts leave the craft.

Another experiment, the "Monodisphere Latex Reactor" will produce tiny spheres in an experiment which will lend itself to the production of pharmaceutical preparations.

Tom Mattingly (right), backup commander for the second and third Shuttle missions. Hartsfield (left) is his pilot. At the time of writing, no crew has been announced for STS-4 but these two astronauts will probably be allocated to the flight. Brand and Overmyer will pilot STS-5 (with Mission Specialists Lenoir and Allen); Weitz and Bobko will fly STS-6 (with Musgrave and Peterson as MS).

NASA

NEW NASA LAUNCHER?

NASA are studying the possibility of building an unmanned launcher from reusable Shuttle components such as the Solid Rocket Boosters (SRB) and main engines to augment the manned Shuttle flights. "SRB-X" will be studied over the next year before any decisions are made but the failure of the Shuttle to satisfy user demands in terms of launch frequency has brought about the situation where NASA are contemplating the introduction of yet another unmanned vehicle.

The stable of expendable launches - Scout, Delta, Atlas and Titan - is being maintained to meet launch schedules.

External Tanks

Observers of the STS-3 launch may notice that the usually-gleaming white External Tank appears to be rather patchy. This is because Martin Marrietta have left off the coat of white paint, allowing the light brown insulation to show through. A saving of 594 lb on the Tank means that the Orbiter can take almost that much more payload into orbit. But Marrietta are aiming to shed a total of 6,400 lb from the Tank by studying data from these early test flights. New materials and construction techniques should achieve that saving by the time the eighth production Tank comes off the line in about three years' time.

NASA has to be careful that an inadequate supply of Tanks does not hold up future flights. Marietta will be producing them at a rate of about 24/year by 1986 and the intention is to push that figure up to 55/year.

Challenger Almost Ready

While *Columbia* was journeying through space, the second orbital Shuttle, *Challenger*, was continuing towards delivery this summer. It was 80% complete according to Rockwell officials, and about two-thirds of the thermal tiles were in place. *Challenger* (pictured in its final assembly bay on p. 64 of the December *Space Education*) is the first operational-configuration vehicle, designed for a 100 mission life and weighing about 2,000 lb less than *Columbia*. The Orbital Manoeuvring pods at the rear will be covered in a high-temperature quilted material instead of the heavier tiles being carried by *Columbia*. The two pilot astronauts will be aided in the landing sequence by head-up displays giving such information as speed and height as they look out through the windows directly in front. Similar devices will be added to *Columbia* when it is removed from service for refurbishment up to operational standards.

NEWS FROM THE CAPE

By Gordon L. Harris

Now in its 24th year, NASA is an agency without a programme, striving to maintain its identity despite inflationary pressures and the Reagan administration's drive to reduce Federal spending.

Coming off the pinnacle of international acclaim for Project Apollo, its last long-range programme, NASA has virtually staked its future, and much of its present, upon a reusable vehicle to ferry people and cargo to and from orbit.

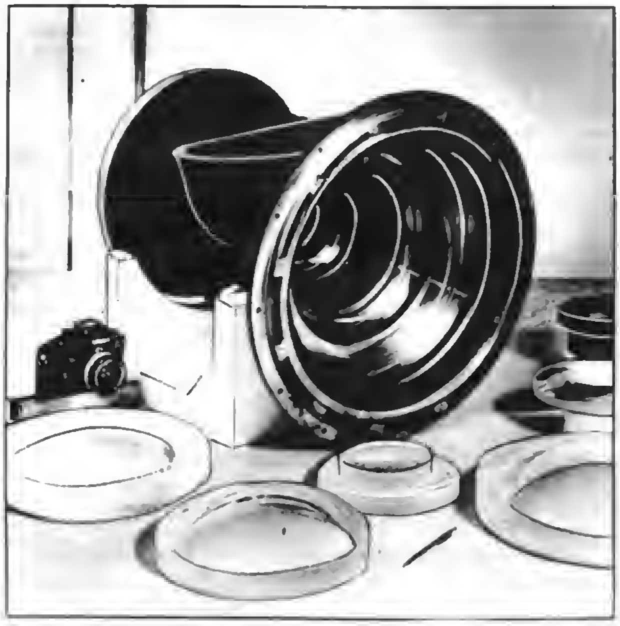
Apollo was drawing to a conclusion with its tenth journey to the Moon in 1972 when NASA chose the Shuttle as its brightest investment in a long range, but poorly defined programme of Solar System exploration and exploitation of space technology.

Having spent over $10,000 million on the overdue Shuttle, the agency wants President Reagan and a reluctant Congress, caught up in larger problems, to approve a permanent orbiting station as the next logical step. Such a structure, agency planners believe, could be assembled from large components carried aloft in Shuttles and maintained indefinitely by ferrying relief crews and supplies. No one has put a firm price tag on the concept but another $10,000 million is a favoured estimate.

Meanwhile, military influence is waxing and civilian interest waning in the projected Shuttle fleet operating from Florida and California.

Chances of the space station being accepted appear to be meagre. The *New York Times* (1 November 1981) reported: "Officials of the National Aeronautics and Space Administration once consoled themselves by saying that when the shuttle got off the ground, they would turn the corner to find, if not prosperity, at least relief from a decade of hard time ... It seems clear they were dreaming."

The President's budget office directed NASA to cut $387 million from its current spending ($6,000 million in Fiscal 1982) and to anticipate reductions of $1,000 million each in the next two years. In response, the agency offered four options from which the President might select one:



The 300 lb lens assembly of Itek's Large Format Camera which will fly aboard the Shuttle for Earth-mapping exercises. Note the size compared with the standard 35 mm camera at left.

ITEK

1. Cancel the Galileo probe to Jupiter and an effort to modify Centaur as an upper stage for Shuttle missions. Close the deep space network and terminate space applications such as improved communications and Earth resources satellites.

2. Eliminate planetary exploration and one of four Shuttles now in production. Continue aeronautical research and applications.

3. Chop most aeronautical work, eliminate applications and the fourth Shuttle but continue planetary missions.

4. Build the four-Shuttle fleet while dropping aeronautical research, applications and planetary probes.

The large space telescope programmed for Shuttle launch in 1985 would survive in any of the four because NASA has already invested millions in that mission.

Adding to uncertainties, Congressional sources said the additional cuts were reduced from $387 million to $151 million, while Shuttle funding remained at $2,100 million this year. What will be dropped from NASA's projects was unknown; however, a proposed mission to Halley's Comet appears dead.

The continued demands of Shuttle development and production have compounded NASA's difficulties; so has the three-year delay in bringing Shuttles to the operational stage. A 1972 promise to eliminate Delta and Centaur vehicles by 1980 or shortly thereafter, relying upon Shuttles to haul satellites and probes into orbit, has simply been conveniently forgotten.

David Grimes, project manager of the Delta expendable vehicle, said that eight will be launched in 1982; he is negotiating for 14 more and buying long-lead components for 27 beyond that figure. Kennedy Space Center's Harold Gay, who launches Deltas, firmly believes the rocket will be around for 10 more years. And Centaurs are scheduled into 1985.

The Shuttle's reusability will turn space travel into a cheap and routine event, NASA and its contractors claim, but that has yet to be demonstrated. Delta's price to commercial users has just been raised from $22 to $25 million, but even that higher figure is much less than the cost of a Shuttle launch: NASA recovers launch costs from commercial users but the agency has to pay for those rockets employed for scientific missions (few and far between).

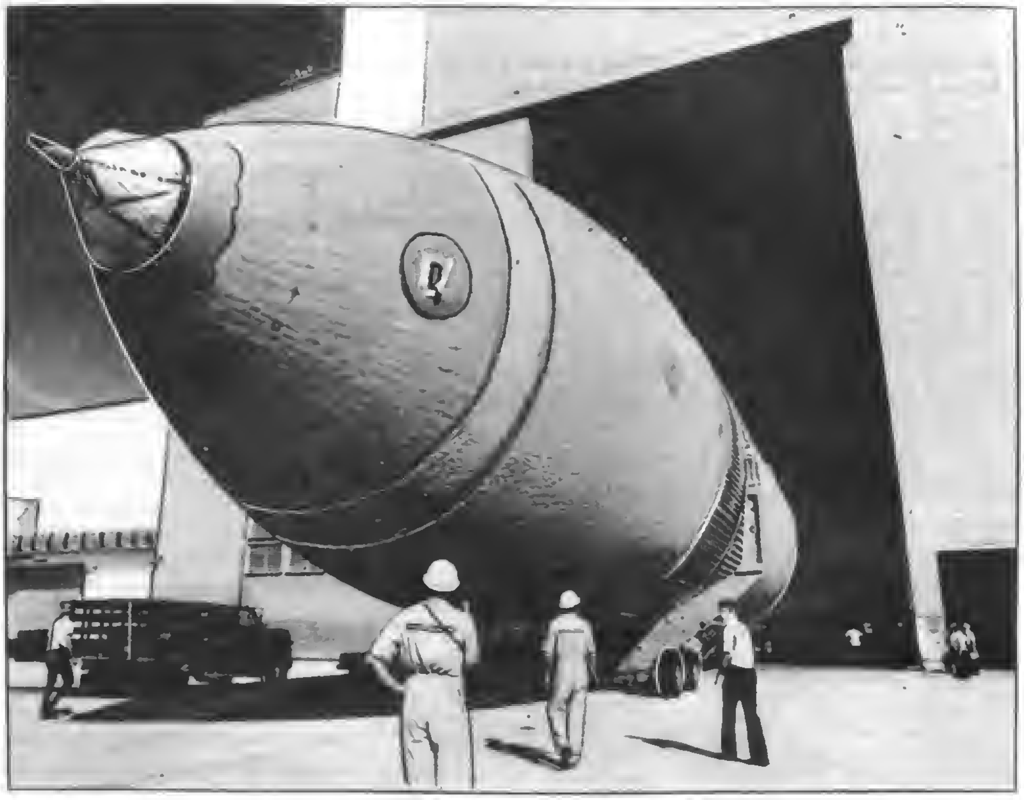
While there has been no indication of Reagen's preferences, the planetary effort depends upon the Jet Propulsion Laboratory, a branch of the California Institute of Technology, supported by NASA funding. It is unlikely that Reagan would shut down JPL.

In any case, NASA has already reduced Shuttle missions. An early 1981 schedule listed 48 flights between 1981 and 1986 but that number was reduced to 32 in May 1981 and there is a strong possiblity that eight more flights will be cut if budget reductions are imposed.

While the money worries plagued agency managers (who are defensive about the Shuttle's performance), a new associate administrator was installed to become boss of the development work. He is Major General James Abrahamson, USAF, who directed the $24,000 million F-16 aircraft project.

The choice of a military manager bears out reports that national defence needs will dominate the Shuttle system's future. Abrahamson confirmed that by talking about it as a weapons carrier from which smaller rockets could power laser devices to destroy hostile satellites.

It was no coincidence that foreign journalists witnessing the second launch of *Columbia* consider the Shuttle an American effort to achieve military supremacy. Seiji Tanaka, a Japanese television figure, said "most of intellectual Japan thinks Shuttle's main objective is to cope with the Soviet Union."



The External Tank for the third Shuttle launch was delivered to the Cape last October.

NASA

Lasse Jensen of Denmark noted that foreign correspondents spoke of the Shuttle's military potential. He said some European scientists fear the US space programme is moving away from science to the military.

What has been an "open" programme will be closed to some degree, General Abrahamson observed. Defence satellites will be installed into Shuttle cargo bays on the launch pad to avoid disclosure and Shuttle-borne television cameras will not reveal their size or shape during the mission.

Journalists at Cape Canaveral are mindful of the pre-NASA era when all launches were military and little was disclosed about their payloads or their failures. "It is a chilling thought to suggest that we may be going back to that kind of environment," one veteran commented.

The state of confusion within NASA about its future prospects thickened a bit after *Columbia*'s shortened second flight when Dr. Hans Mark, deputy administrator, revived a 20-year-old political feud between Florida and Texas. Mark wrote a six-page paper about NASA's outlook, parts of which became public when newsmen questioned him.

Mounting concern over Shuttle costs – $3 million a day was the estimate when STS-2 was delayed from 4 November to the 12th – prompted Mark to suggest the unthinkable: returning Mission Control from Houston to the Cape. His bravery won salutes in Florida and something else in the Lone Star State!

Early manned space missions, Mercury and Gemini, were controlled from a one-storey, concrete block building on Cape Canaveral, a poor man's forerunner for the massive telemetry complex at NASA West (as the Johnson Space Center is sometimes referred to by press). Texan politicians reacted at once, led by Vice President George Bush who visited mission control before astronauts Engle and Truly returned and said, "This is a national treasure and will be preserved."

Mark implied some disagreement within the agency over Shuttle's status, saying that if costs are to be reduced, the "developmental" attitude of JSC must change.

Chairman Don Fuqua of the science and technology committee, House of Representatives (the committee that authorises NASA budgets), walked into a similar confrontation three years ago. A Florida resident, Fuqua thought that Shuttle astronauts ought to live near the launch base if NASA intended to fly 30-40 missions per year. JSC spent $500,000 on an urgent study to prove him wrong and the committee did not pursue the matter.

Dr. Mark's paper also emphasised the advantages of a large space station as one good way to justify the Shuttle fleet. But the Reagan people and Congress have demonstrated little enthusiasm for more big-spending space projects.

"SPACE EDUCATION"

The Society has already distributed two issues of *Space Education* (July and December 1981). We plan two further issues in 1982, May and September, but now they are available on a separate subscription of £3.00 ($8.00).

Planned articles include: a review of what we can learn about the Earth from observing the motions of satellites; a detailed listing of unmanned space exploration, how space is affecting the way we handle information, plus a model for demonstration polar-orbiting satellites.

Space Education is one of the Society's exciting new ventures. Don't miss out – remember to add it to your Membership-Renewal form or apply directly to the Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Rd., London SW8 1SZ.

SPACEFLIGHT

Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 27/29 South Lambeth Road, London SW8 1SZ Tel: 01-735 3160.

Correspondence and manuscripts intended for publication should be addressed to the Editor, 27/29 South Lambeth Road, London SW8 1SZ.

Opinions in signed articles are those of contributors and do not necessarily reflect the views of the Editor or the Council of the British Interplanetary Society, unless such is expressly stated to be the case.

Continued from inside back cover

Technical Forum

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ on **Friday, 5 June 1982**, 6.30–9.00 p.m., and **Saturday, 6 June 1982**, 10.00 a.m. to 12 noon and 1.30–3.30 p.m.

Topic: **THE SOVIET SPACE PROGRAMME**

It is anticipated that papers will be given at the Friday evening and Saturday afternoon sessions, with some Soviet space films being shown during the Saturday morning session.

Offers of papers are invited. Further information may be obtained from the Executive Secretary of the Society, Members with a special interest in the Soviet space programme are invited to attend. A registration fee of £2.00 is payable. Forms are available from the Executive Secretary on request, enclosing a stamped addressed envelope.

33rd IAF Congress

The 33rd Congress of the International Astronautical Federation will be held in Paris, France from **27 September-3 October 1982.**

Theme: **SPACE ACTIVITIES OF THE YEAR 2000**

Members of the Society wishing to present papers are asked to notify Dr. L. R. Shepherd, Chairman of the BIS International Liaison Committee at Society H.Q. as soon as possible. Members wishing to present papers to the IAF Student Conference must submit them through the Society.

Film Show

Theme: **STEPS TO THE MOON – 1**

A series of film programmes to sketch the story of man's Exploration of the Moon. The first will be screened at a meeting to be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **6 October 1982**, 7-8.30 p.m.

The programme will include the following:

(a) Destination Moon — The Story of Project Ranger
(b) Close Up — A Look at Lunar orbiter
(c) Project Apollo: Manned Flight to the Moon
(d) Steps to Saturn
(e) Landing on the Moon

Admission is by ticket only. Members wishing to attend should apply in good time, to the Executive Secretary, enclosing a stamped addressed envelope.

Space Systems Conference

Theme: **THE SPACE TRANSPORTATION SYSTEM**
A Review of its Present Capability and Evolution

A three-day meeting to be held in Washington, D.C. USA on **18–20 October 1982**, sponsored by the AIAA, AAS, NSC, DGLR, JAS and cosponsored by the BIS.

Subject areas to be covered include:

(a) The Space Shuttle Orbiter
(b) Orbital Transfer Vehicles
(c) Reusable vs. Expendable Launch Vehicles
(d) Man's Role in Ground and Flight Operations
(e) User Needs for a Space Truck
(f) The Orbital Facility Applications

BIS authors intending to present papers should, in the first instance, contact the Executive Secretary, 27/29 South Lambeth Road, London, SW8 1SZ. The same applies to members of the Society who plan to attend the Conference.

Lecture

Title: **UPDATING QUASARS**

by Dr. R. Carswell
Observatorio Interamericano De Cerro Tololo

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **20 October 1982**, 7.00–9.00 p.m.

Please note that the date given is provisional and may change.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Film Show

Theme: **STEPS TO THE MOON – 2**

The second programme in this series will be screened at a meeting to be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **27 October 1982**, 7.00-9.00 p.m.

The programme will include the following:

(a) Assignment Shoot the Moon
(b) Apollo/Saturn V Lunar Mission
(c) Debrief Apollo 8
(d) Apollo 9 - The Duet of Spider and Gumdrop
(e) Apollo 10: Green Light for a Lunar Landing

Admission is by ticket only. Members wishing to attend should apply in good time, to the Executive Secretary, enclosing a reply-paid envelope.

OUR SPACE LIBRARY

We are seeking many technical books and similar items on astronomy, space research and space technology, and would welcome hearing from members with material they would like to donate to us to help fill the gaps.

Please write to the Executive Secretary first of all, indicating what you are willing to present to us.

The Library will be open to members from 5.30-7.00 p.m. on each of the following dates:

10 Feb. 1982	24 Feb. 1982
10 Mar. 1982	11 Mar. 1982
24 Mar. 1982	31 Mar. 1982

While every effort will be made to adhere to the published programme, the Society cannot be held responsible for any changes made necessary for reasons outside its control.

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REUSABLE SATELLITE PLATFORMS

THE NEXT GENERATION OF EARTH ORBITAL SYSTEMS

By D. E. Koelle

The Shuttle will allow astronauts to retrieve satellites from orbit and bring them back to Earth for modifications and relaunch. With this capability in mind, structures can be designed to carry a whole range of payloads. Here, a German concept is described which should see its first mission during the seventh Shuttle flight early next year.

Introduction

The era of reusable launch vehicles, inaugurated in 1981 by NASA's Space Shuttle, paves the way for a new concept in space operations: reusable platforms for LEO (Low Earth Orbit) missions.

Such platforms are characterised by multiple re-use after retrieval from space by the Shuttle. The platforms will be refurbished, equipped with modified or new experiments, or material processing facilities, and relaunched.

The idea is to reduce spacecraft cost per mission. While a dedicated satellite presently costs $30-60 million, the reflight concept could bring this down to $10-20 million per mission, assuming three reflights with the associated retrieval and refurbishment cost. It makes sense especially for relatively short mission periods of several weeks or months (up to one year).

Such missions, however, will become of growing importance in the future, especially for materials processing, special Earth observation tasks, dedicated astronomical observations, test and qualification of complex space instrumentation (helium cryostats, radar and laser systems).

Mission opportunities will occur frequently since it is evident that long Shuttle stay times in orbit will be difficult to achieve because of operational problems (too few Shuttle vehicles are available for the expected number of launches).

Platform Design Features

Since the American Shuttle will be the only available reusable launcher in this decade, the platforms have to be designed for that vehicle. This leads to following design ground rules:

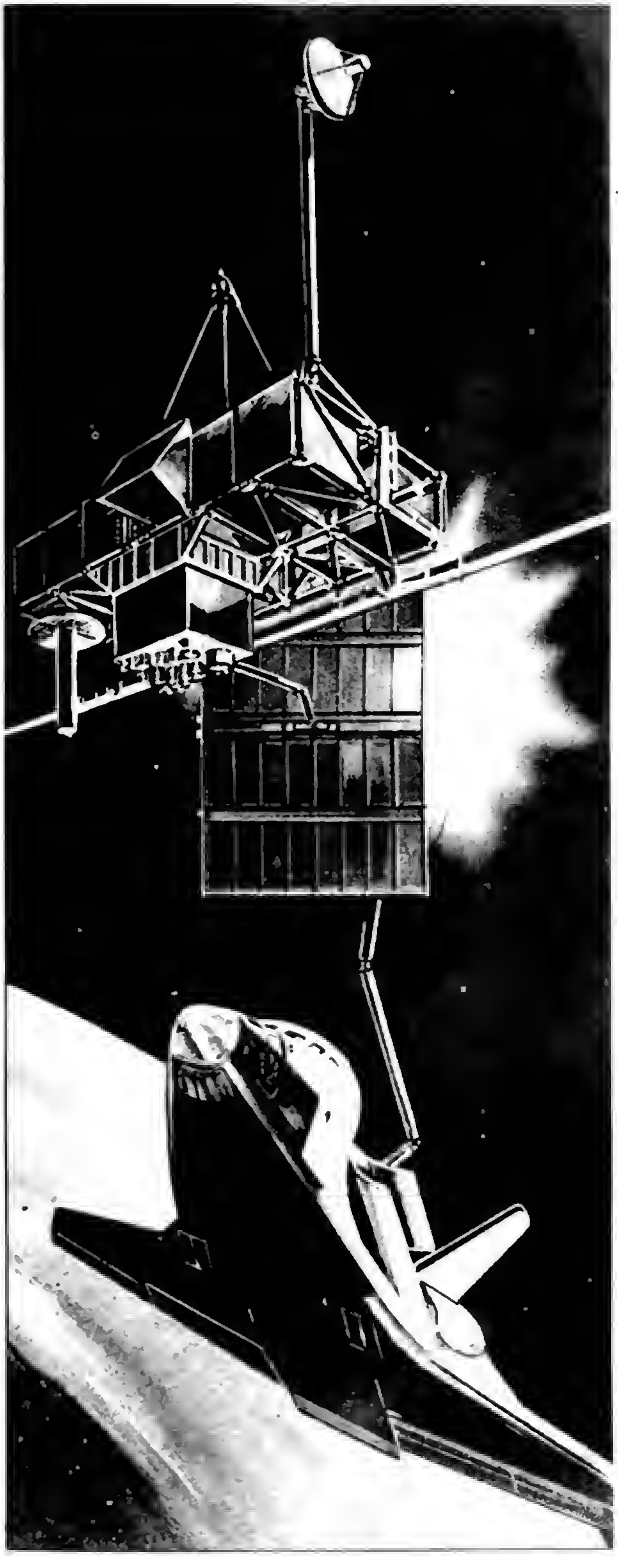
- standard width 4.4 m (across cargo bay)
- shortest possible length (determines the launch cost)
- total mass in accordance with length (about 1650 kg/m for 28° standard orbit)
- platform-integrated propulsion for transfer to higher orbits
- no cradle.

The last aspect is very important: the design must avoid any additional cradle support structure in the cargo bay, otherwise retrieval cost would be essentially increased. This has led MBB to conceive a modular truss structure consisting of standardised elements using CFRP (Carbon-fibre Reinforced Plastic)-tubes and titanium node interconnections. This combination provides high stiffness and avoids thermal deformation. The structure size can be easily increased in 70 cm steps.

The platform interconnection consists of two sill fittings and one keel fitting (which remains with the platform). Experiments and subsystems are mounted on standard-size panels attached to the node points.

SPAS-01-Shuttle Pallet Satellite

The first experimental version of this platform is SPAS-01. MBB decided in 1979 to go ahead with a Company-funded project in order to prove the feasibility and advantages of a



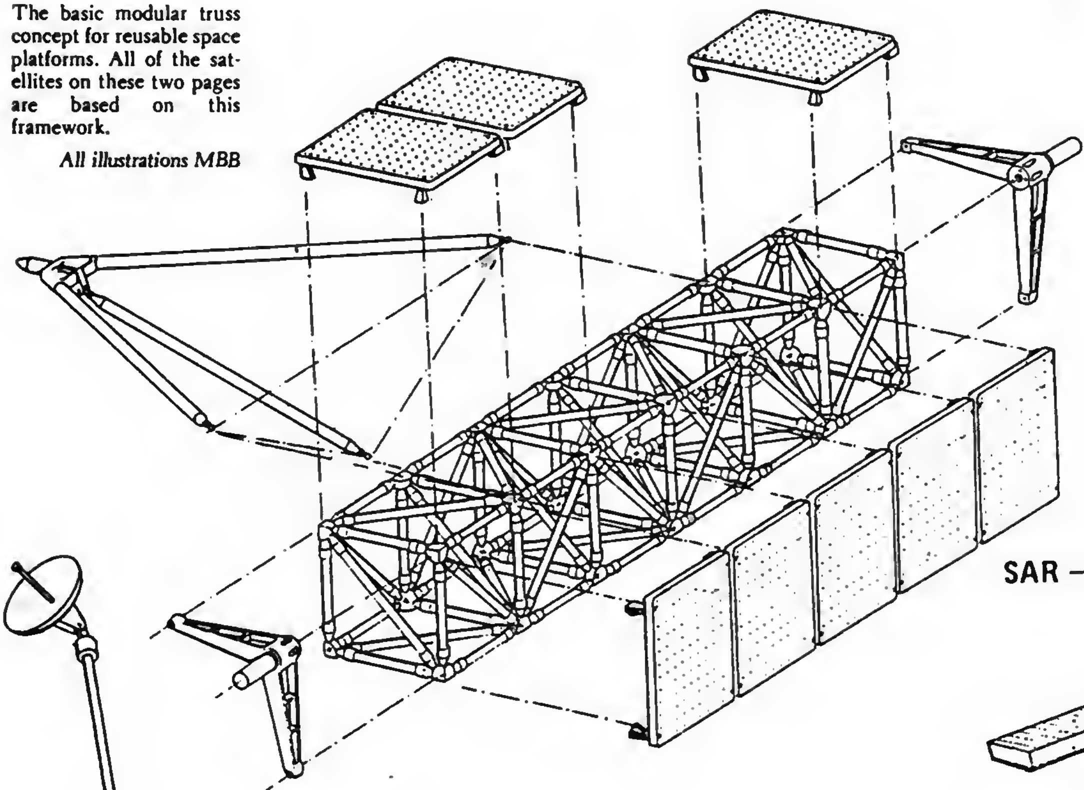
Argus-SPAS is an Earth resources platform based around the basic truss structure, with an aim of providing low-cost commercial remote sensing.

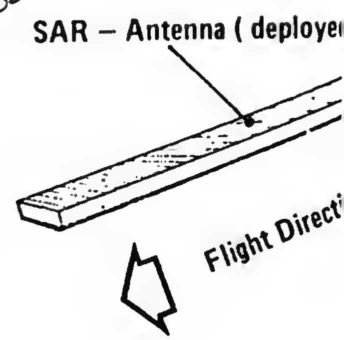
MBB

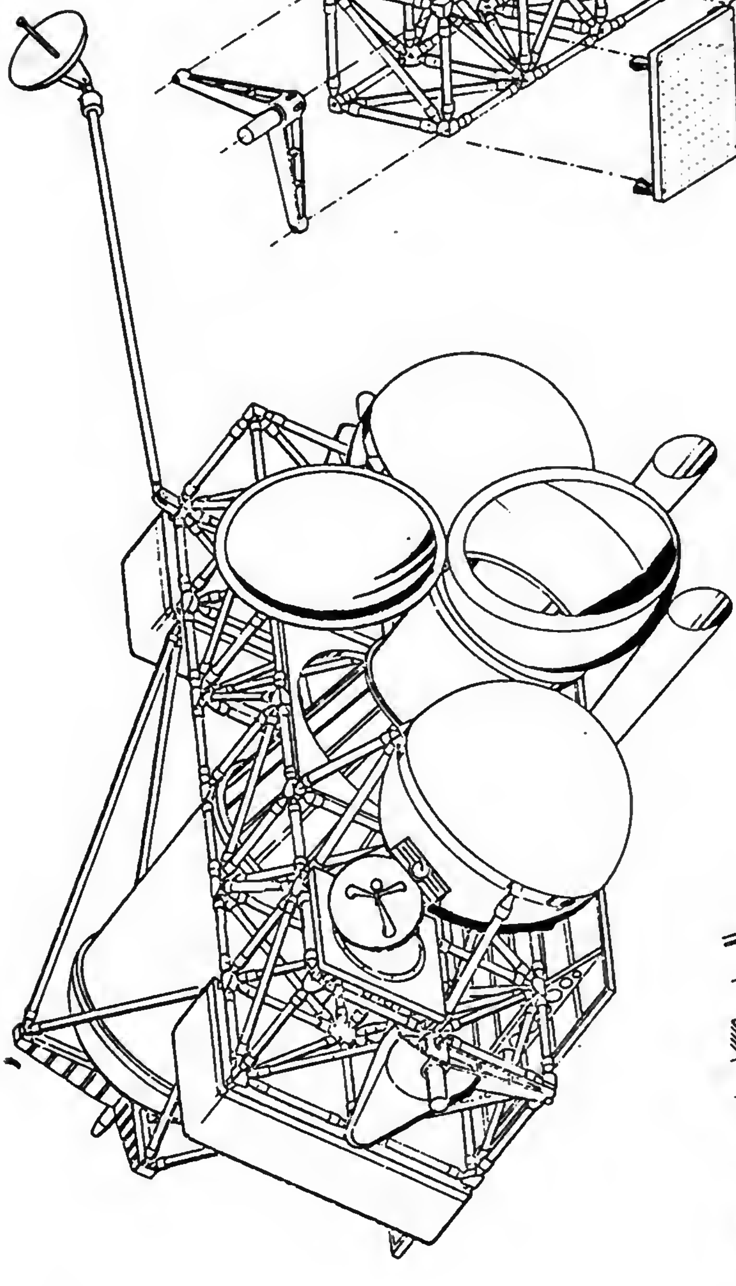
SPACE PLAT

The basic modular truss concept for reusable space platforms. All of the satellites on these two pages are based on this framework.

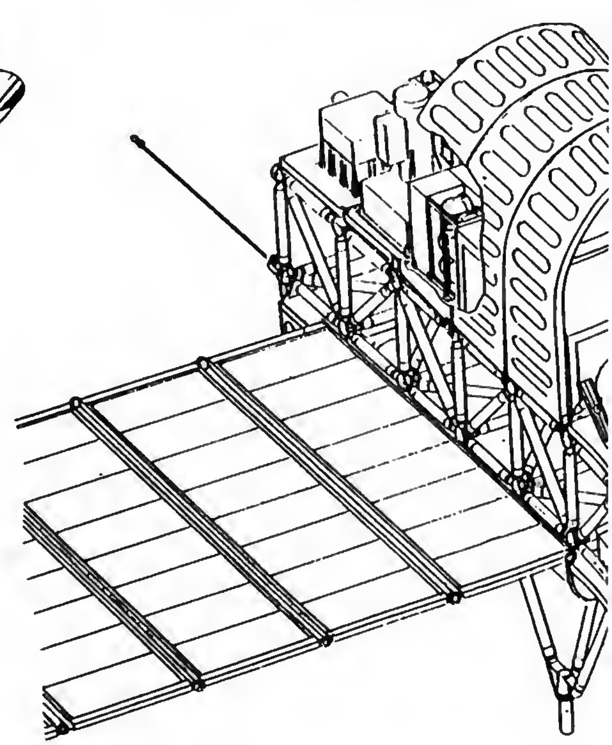
All illustrations MBB



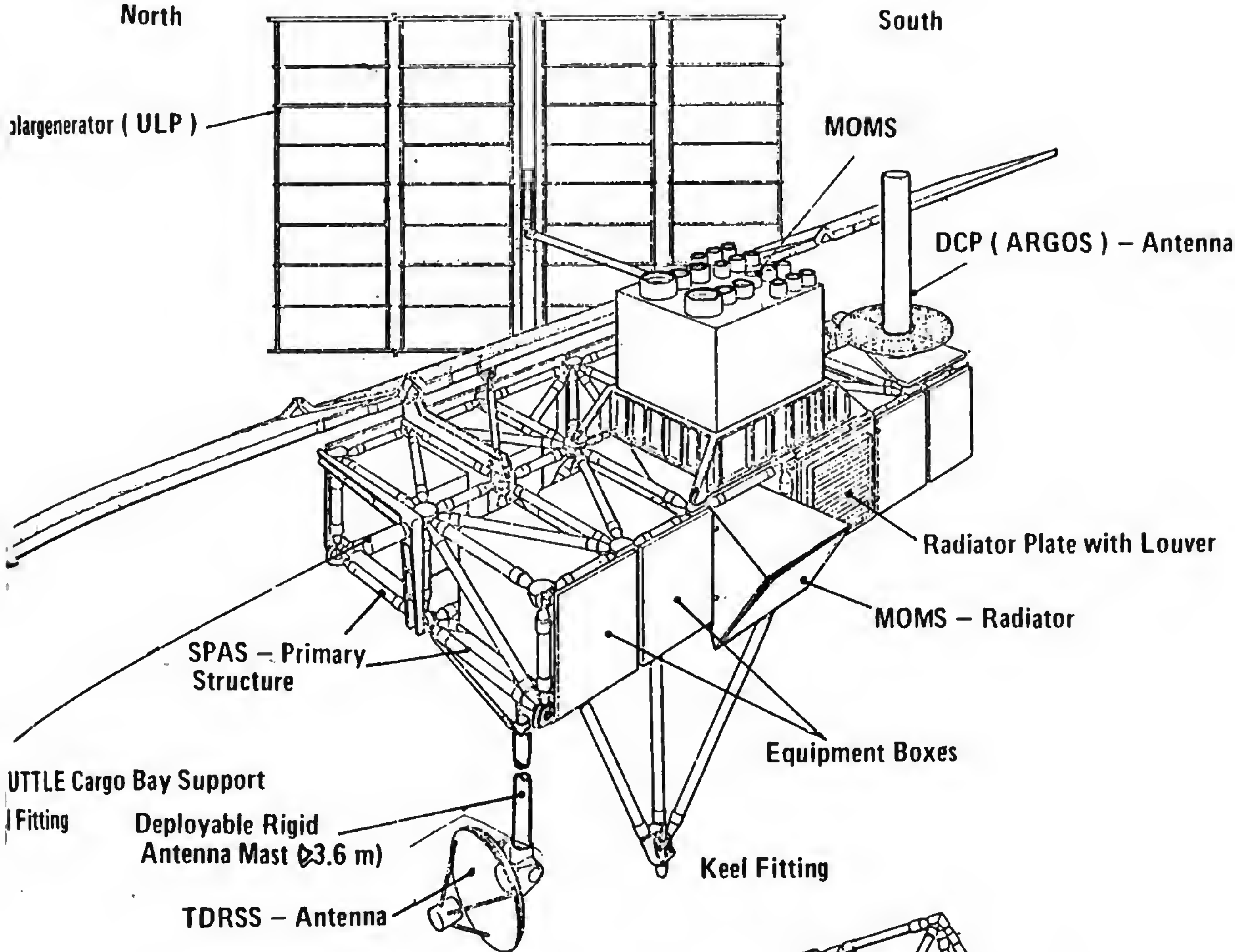


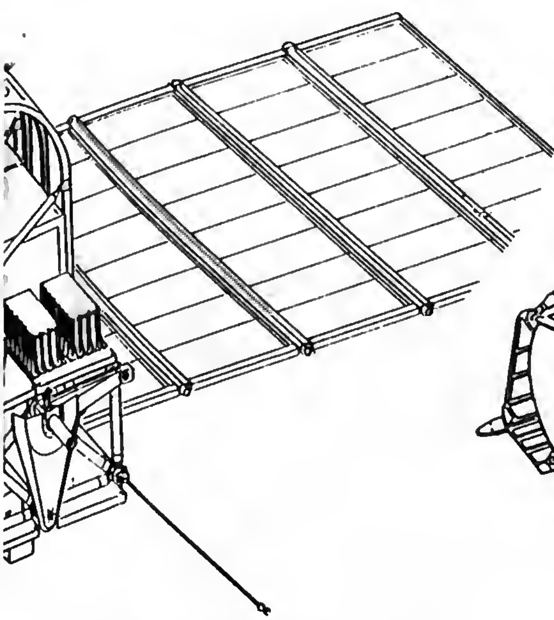


The Argus SPAS platform (pictured earlier bei released from the Shuttle's cargo bay) could be us for commercial Earth observations missions.

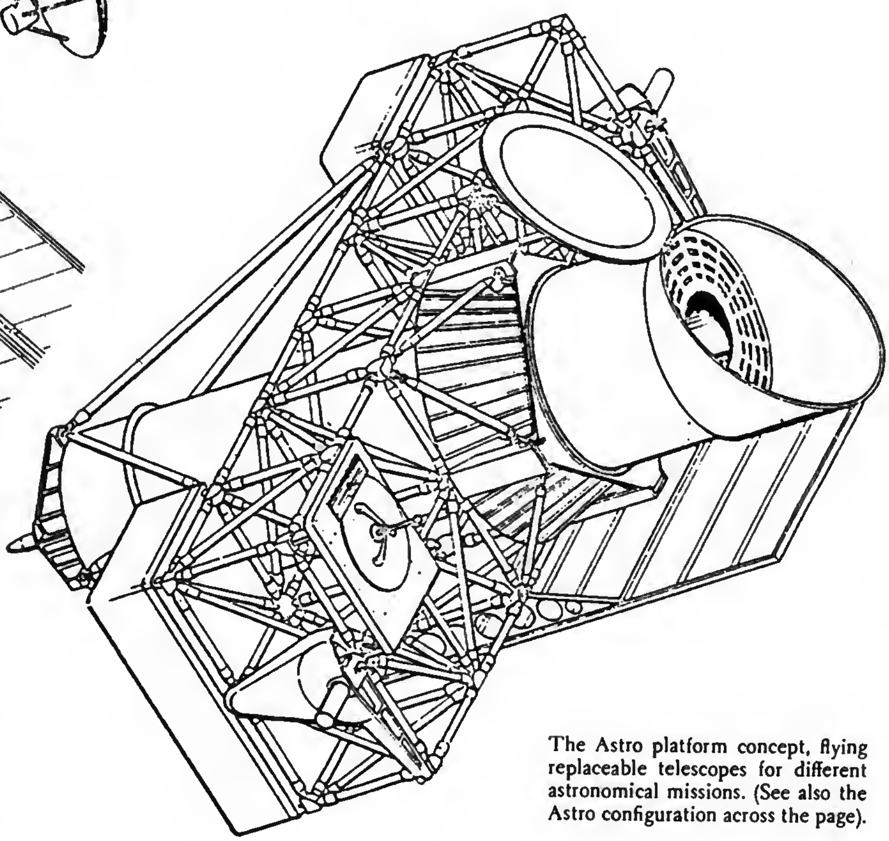


ꝚM CONCEPTS

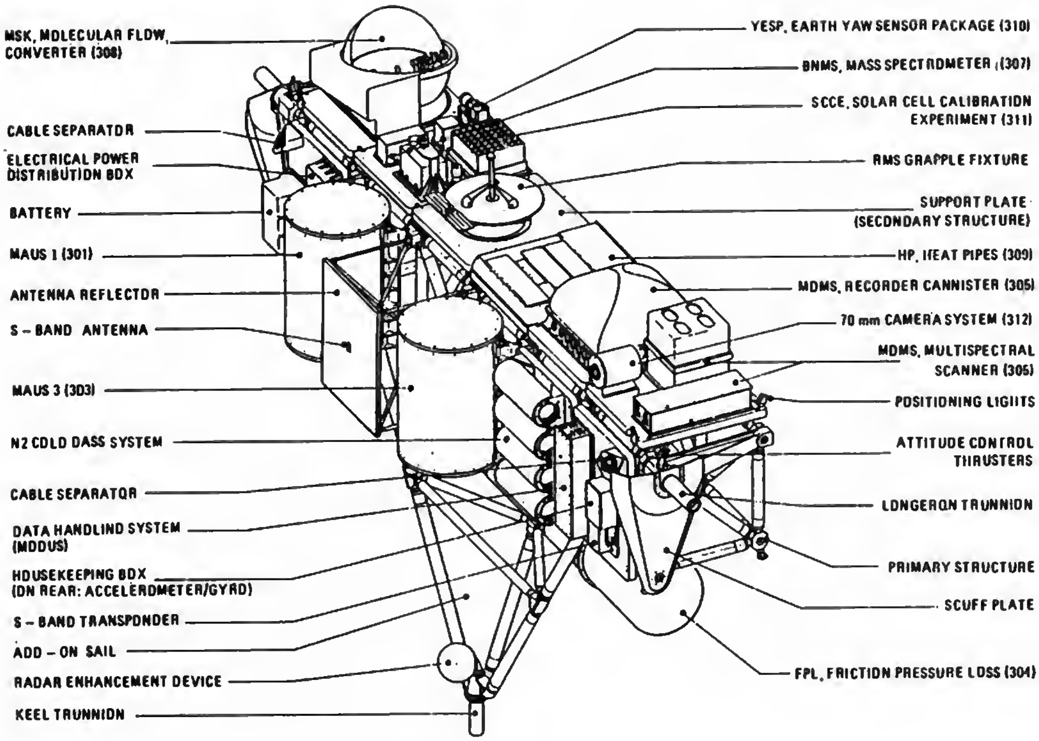




A preliminary concept of a Micro Gravity Platform for materials processing activities in orbit.



The Astro platform concept, flying replaceable telescopes for different astronomical missions. (See also the Astro configuration across the page).



SPAS-01 will be launched by the Shuttle next year to demonstrate the basic concept.

MBB

reusable platform. At the same time, this meant the introduction of a new commercial approach: MBB builds the platform from its own specifications and sells the service of flying experiments for a charge of $10,000 per kg on average. BMFT, the German Ministry of Research and Technology, supported MBB and agreed to charter the flight opportunity for a number of technological and scientific experiments. The fee was negotiated for 300 kg of active experiments (requiring power support and data handling) and 700 kg of passive experiments for a fixed fee of DM13.5 million.

Finally, NASA showed interest in using this "mini-platform" for Shuttle payload operations training, especially for deployment, approach and retrieval tests. The charge negotiated for this service led to an essential reduction of the launch cost to $4 million for an occupied cargo bay length of 1.5 m (including special services).

The total mass of SPAS-01 is 1700 kg, with 950 kg of that devoted to 10 experiments. The structure assembly was completed in September 1981 (with no special rigs or tooling required) and the spacecraft itself will be finished by mid-82 in time for launch by Shuttle flight No. 7 (scheduled for March 1983). It will be the heaviest European spacecraft flown to date.

Flight time will be relatively short: two days within the cargo bay (attached mode) and one day in the deployed mode. This requires a simple attitude stabilisation system with gas thrusters, battery power supply and a telemetry/telecommand system.

A reflight of SPAS-01 is planned later with a modified set of experiments.

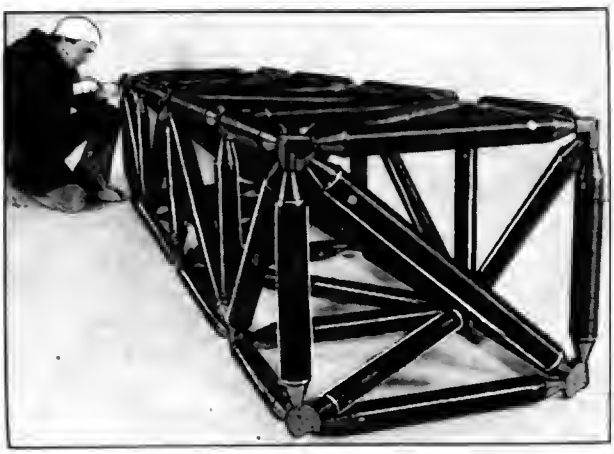
Future Platforms

Various space platform concepts are being studied. One is the Astro-Platform which would carry various types of telescopes. Both X-ray and Infrared (cryogenically cooled) telescopes are under development in Germany for multiple missions.

Another is the Microgravity Platform, in the 2000-3000 kg class, for materials processing. Detailed studies will be made this year and the earliest launch date is 1986.

"Argus-SPAS" is an Earth resources platform which could commercially supplement the work of, for example, Landsat and SPOT. The aim would be to perform short missions, such as mapping or searching for minerals in one country, with an emphasis on low costs.

Looking further into the future, a manoeuvrable larger platform in the 3000 to 7000 kg range could be built, with propulsion capability into even geosynchronous orbit. A standard platform seems feasible to carry payload modules instead of single experiments, thus reducing the ground preparation and integration periods.



The basic SPAS structure.

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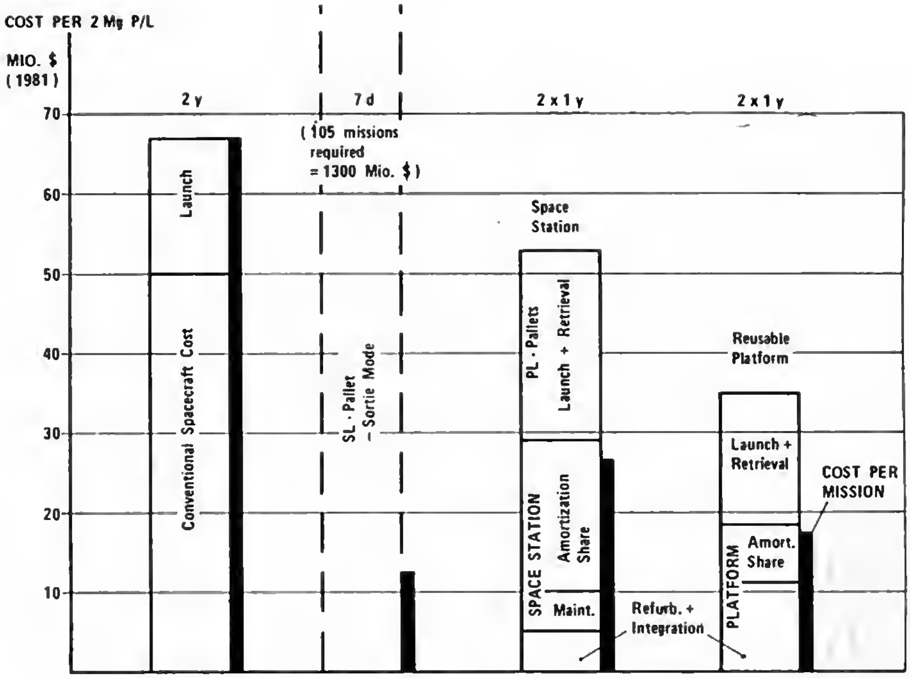


Mission cost comparisons for a 2,000 kg payload and 2 years of orbital operations (the "2 Mg P/L" on the vertical axis refers to a 2000 kg payload).

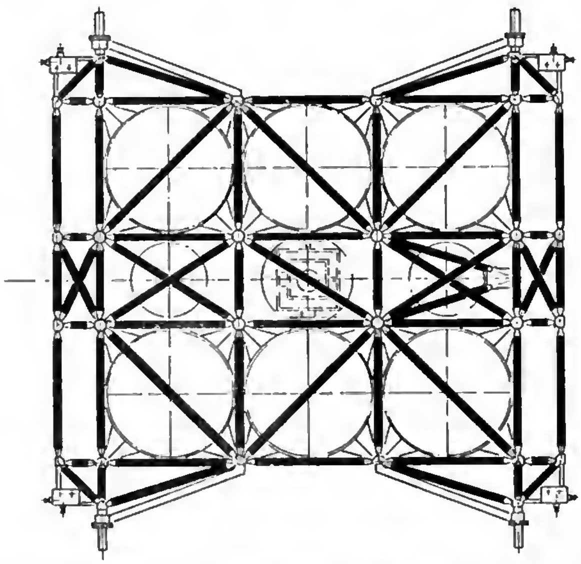
Platform Economics

The graph above allows us to make cost comparisons between differing flight modes for a 2,000 kg payload package with 2 years of operation. The modes are:

1. Conventional expendable spacecraft with 2 year lifetime (i.e. a single 2 year mission).
2. Spacelab pallet/Shuttle sortie mode with repeated 7 day missions.
3. Pallet-mounted package attached to a large permanent space station (unmanned-platform); two missions of 1 year each.
4. Reusable small platform with two missions of 1 year each.

As can be seen from the graph, the cost per mission is lowest for the Spacelab pallet sortie mode - but the *total* cost is excessive because of the large number of missions required. (In these cost comparisons, the Shuttle is assumed as the launcher, with the same launch cost assumptions: $35 million in 1981 terms.)

The space station approaoh, costed upon the data provided by W. C. Snoddy (in *Astronautics and Aeronautics*, April 1981), would be a more economic approach compared with expendable spacecraft or repeated Shuttle flights. Reusable platforms, however, are even lower in overall mission cost. These two models are about equal in specific mission cost only if the amortization cost of the (permanent) space station is disregarded. For Europe, however, the large investment cost for a permanent space station, requiring more than $500 million and the development of new technology and space operations, (automatic rendezvous and docking systems, servicing and repair techniques, etc.) is not likely to come about during this decade. This may be a goal for the 'nineties if reusable platform operations lead to industrial activity in Earth orbit.



Conceptual design for a larger multipurpose platform (3.5 × 4.5 m) with payload modules and orbital manoeuvring capability.

SPACE REPORT

NEW UK SATELLITE

The UK has agreed to contribute a free-flying sub-satellite (UKS) to the Active Magnetospheric Particle Tracer Explorers (AMPTE) project which is due for a Shuttle launch in 1984. The two other satellites are being built by the Americans and Germans (described in last month's *Space Report*).

During lauhch, UKS will form the structural link between the German and US spacecraft, but thereafter will keep station within 100 km of the German spacecraft – the Ion Release Module (IRM) – in order to study a series of barium and lithium ion releases to be made from IRM. There will be a total of seven such releases into the solar wind and radiation and plasma environment of the Earth over the nine months of the mission. The American satellite – the Charge Composition Explorer (CCE) – will orbit through the radiation zones closer to the Earth in order to detect the arrival of the "tracer" ions. The three satellites will also join forces to make extensive measurements with unprecendented resolution of the Earth's natural plasma envirnoment.

One release of barium ions, planned near Christmas 1984, will create what will appear from the ground for some 30 minutes as an artificial comet, interacting with the solar wind in much the same way as a real comet. The releases will be visible mainly from North and South America where a suitable chain of ground observing stations and spotter planes can be made available.

The release of the tracer gases from the IRM will trace the flow of matter and energy from the solar wind into and through the Earth's magnetosphere, while simultaneously examining the complex sequence of plasma processes triggered by such releases. The experimenters expect to observe a rich spectrum of plasma waves, electron and ion acceleration and the formation of a magnetic cavity among many other phenomena.

Although weighing only 69 kg, UKS is nevertheless highly complex. The satellite will be controlled via the 12 m dish antenna at the Rutherford Appleton Laboratory to remain within some 100 km of the IRM using an on-board radar and propulsion system. The instruments will measure magnetic fields, detect positive ions in the energy range 5 eV–20 keV, detect electrons in the energy range 40 eV–25 keV, investigate wave/particle interactions including positive-ion and electron modulations, and detect plasma waves by making measurements of the electric and magnetic components at frequencies from 0.1–64 Hz.

FAGET RETIRES

Maxime A. Faget, father of the Mercury spacecraft, retired from NASA shortly after the STS-2 mission to be a consultant and to carry out private investigations of several energy conservation schemes.

Faget, Director of Engineering and Development at the Johnson Space Center since 1961, said that he planned to remain closely associated with the space programme as a consultant.

Faget joined the Langley Research Center in 1946 as a research scientist into pilotless aircraft. He was later named head of performance aerodynamics, a post he held until 1958.

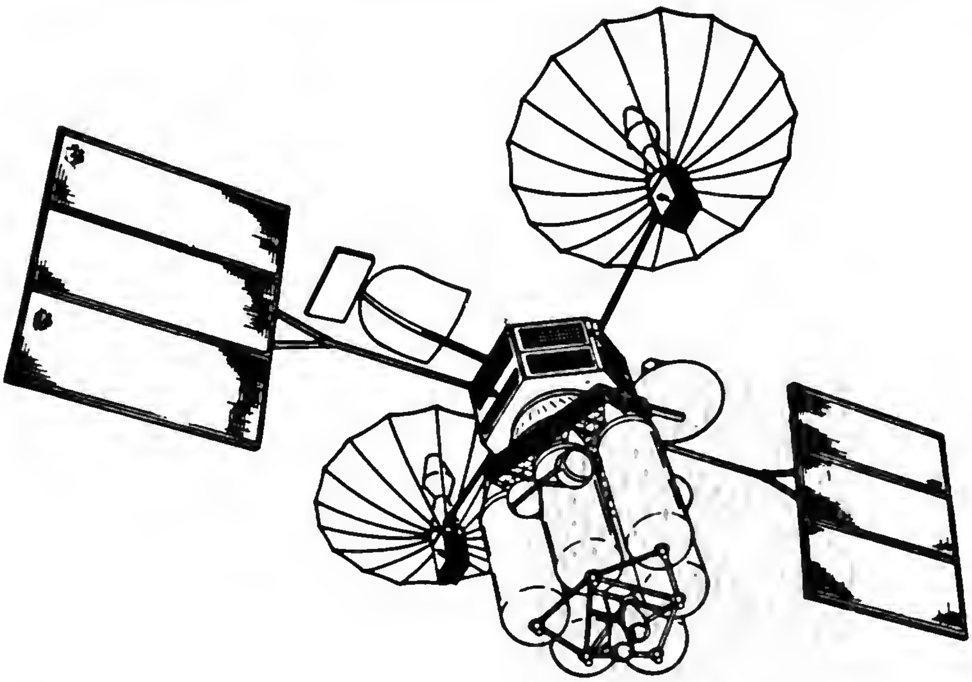
His creative drive and engineering perception resulted in his selection as one of the original group of 35 assigned as a nucleus of the Johnson Space Center (then the Space Task Group), serving three years as Chief of the Flight Systems Division.

PROPULSION MODULE

The Inertial Upper Stage (IUS) will be used in conjunction with the Shuttle to take payloads into geostationary orbits (GEO) – but other stages may appear. A TRW study – described by Dr. Brodsky in his paper "An Economical And Flexible Alternative Orbital Transfer Vehicle" presented at the 32nd IAF Congress – proposes an all-liquid low-thrust propulsion module.

The study took the case of a growth version of the TDRS communications satellite which the present all-solid IUS would be unable to handle.

Propellants for the module – nitrogen tetroxide and monomethyl hydrazine – would be stored in six tanks arranged within a framework, using a pressure system to feed two 300 lbf engines of the type used on the Viking Mars missions. This initial version could take about 5200 lb into GEO but masses of up to 10,000 lb could be handled by increasing the tanks'



The TRW propulsion module mounted on a TDRS communications satellite.

TRW

lengths.

Although the specific impulse of this system is comparable to that obtainable from the IUS solid motors, important gains in performance and cost come from weight savings and equipment reduction. The latter is achieved by avoiding duplication of many functions readily available from the spacecraft which the propulsion module is transporting.

COMPUTERS IN SPACE

We may see computer systems in space as early as the 1990's in an effort to improve their efficiency. As computers become faster, their cooling requirements will increase and some designs may require cooling down to almost absolute zero (−273°C) in order to operate.

The simplest way of doing this would be to put the whole machine in space and communicate with it just as we do today with other satellites. One advantage (although possibly a drawback from the security angle) is that a computer in geostationary orbit will be available to an entire hemisphere.

SOLAR SYSTEM ORIGINS

Two scientists at NASA's Ames Research Center have contributed significantly to changing scientific thinking regarding the origin of the Solar System.

Previously, the Solar System was thought to have originated from part of a huge, thin and cold cloud of interstellar matter that contracted into a more dense uniform cloud of hot gases and dust called the solar nebula. As the nebula cooled, mineral grains formed by condensation. The dust and grains aggregated into small, solid bodies; and these so-called planetesimals were consolidated into the planets, moons, comets and asteroids. According to this theory, the first formed planetesimals of the Solar System should contain roughly the same proportions of the rock-forming elements as are found in the Sun.

Earlier studies found such a similarity in a special class of meteorites (carbonaceous chondrites), once considered to be primitive or unchanged examples of these first formed planetesimals.

But recent findings revealed that these chondrites were not primitive but, in fact, had gone through chemical changes.

COMET-SUN COLLISION

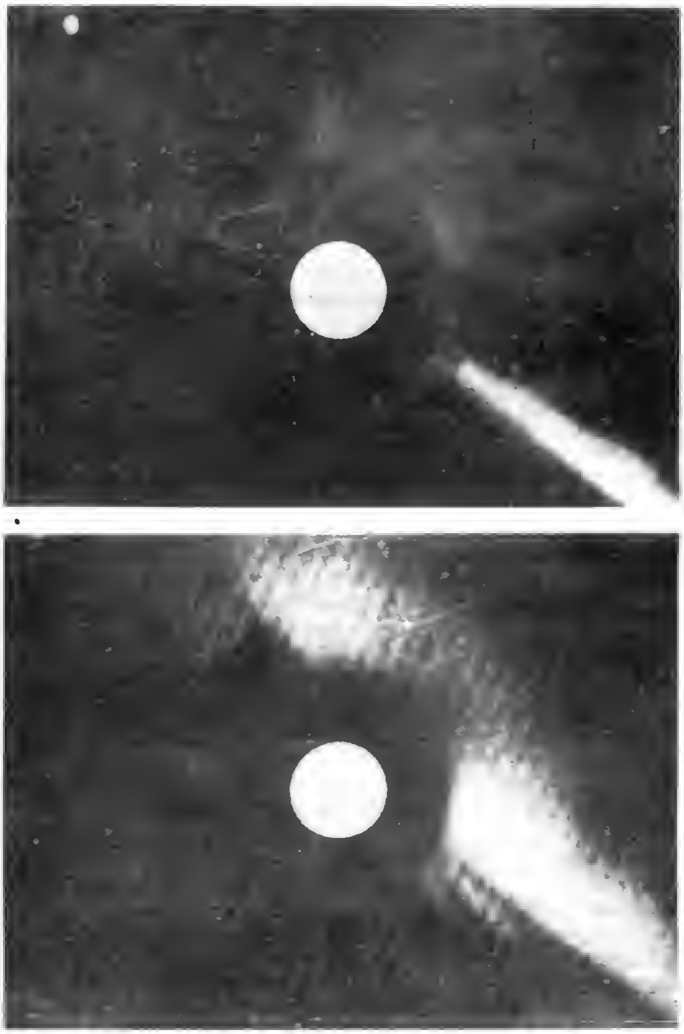
Data being analysed from a coronagraph aboard the USAF P78-1 satellite has shown that a Sun-grazing comet actually hit the Sun on 30 August 1979, scattering debris throughout the corona. The instrument showed the comet approaching and then debris being blown away after the collision.

"The discovery occurred quite by chance," said Dr. Donald Michels, Chief Scientist for the Naval Research Laboratory's Solwind experiment, the instrument that recorded the event. The instrument provides a view of the corona similar to that seen from the ground during a total solar eclipse. To do this, the coronagraph has its own "artificial Moon", or occulting disk, which provides a continuous "solar eclipse" for the instrument. "Total eclipses observed from the Earth last no more than a few minutes," says Michels, "while Solwind has been able to observe the Sun's corona through these artificial eclipses night and day for nearly three years."

According to Michels, the comet passed through the instrument's field of view as it streaked on its collision course with the Sun. It quickly disintegrated upon impact in the Sun's blazing heat. The long delay in discovering the event is because the relevant data has only now been released for analysis.

NRL researchers believe that the new comet may have been one of a special group following orbits that pass very close to the Sun. Known as "Sungrazers," these comets skim the solar surface in near-miss trajectories. About eight such comets have been sighted over the past 300 years, but many more may have escaped detection due to the difficulties sometimes experienced in observing them from the Earth. "For example, the comet detected by Solwind was not sighted from the ground even though its tail was brighter than Venus," said Michels.

NRL researchers are now checking with ground-based observatories for any telltale signs of the comet's entry into the Sun's atmosphere. "We estimate that when the comet hit the Sun, energy of about 10^{30} ergs was released, about 1000 times the energy used in the US during an entire year," says Dr. Michels. "But this is insignificant when compared to the Sun's normal energy output. As a result, it may be difficult to find other evidence of the collision on the Sun's chaotic surface."



Images from the Solwind coronagraph show (top) the comet approaching the Sun at over 600,000 m.p.h. with a tail over 3 million miles long streaming out behind it, and then (below) cometary material spreading through the corona about half a day later. The small bright dot is the planet Venus.

NRL

Prime and backup crews for the joint Soviet-French mission expected this year. Right to Left: Yuri Malyshev, Jean-Loup Chretien, Alexander Ivanchenkov; backups: Patrick Baudry, Leonid Kizim and Solovyov. There have been hints that the flight may take the crew up to Salyut 6 instead of a new Salyut 7 space station.

Novosti

The researchers found at least three different kinds of clays in the carbonacious chondrites. The conventional theory hypothesized that these clays formed by reactions between gas and dust in the solar nebula prior to consolidation into small bodies. However, the clays show no evidence of this gas/dust origin. Instead, evidence indicates they formed in ways similar to those of some clays on Earth. These sorts of processes could only have occurred on the parent body of the meteorite and could not have occurred in the solar nebula gas/dust cloud.

The three different clays also had three different chemistries. If the solar nebula theory were true, the clays should have more or less a uniform chemical composition. The differences in the clays could be readily explained, however, by the action of water on the minerals in the surface of a small body.

The two researchers now believe the carbonaceous chondrites probably broke away from asteroids or comets after this process had taken place. Thus the chondrites are not unchanged, primitive samples of the past.

This raises the possibility that the water and some of the water-soluble material, including organic compounds, in these meteorites were originally formed in interstellar space before the origin of the Solar System.

Thus, scientists, through the study of carbonaceous meteorites, may be able to look backward in time and determine what was occurring in interstellar space before the Solar System was beginning to form, more than 4,500 million years ago.

The two researchers suggest a new model, the "cosmic raisin muffin" model. In this model, when the Solar System was forming, the bodies that aggregated at great distances from the Sun in the very low temperature regions - possibly comets - were composed mostly of ice mixed with rocky material and dust, like raisins in a muffin. Nearer the Sun, as close as the outer regions of the astroid belt, the carbonaceous meteorites formed. They were made of mostly rocky matter with chunks of ice imbedded in them.

ESA/JAPAN COOPERATION

The seventh ESA/Japan meeting to review cooperation on space activities took place in Paris on 2-4 November 1981, with several Working Groups discussing some items in detail.

Both Japan and ESA will be sending spacecraft to study Comet Halley when it reappears in 1985. To ensure that maximum advantage is taken of this unique opportunity, Japan and ESA are coordinating their missions as closely as possible. Both parties have also established working relationships with the USSR and the USA within the framework of the Inter-Agency Consultative Group on Space Missions to Comet Halley.

In about a year from now, both Japan and ESA will have X-ray astronomy observatories in orbit and astronomers will be encouraged to ensure that the two observing programmes support one another so that the maximum scientific return can be achieved.

In the field of Earth Observation Programmes, significant progress was made in the coordination of the Japanese (GMS, MOS-1, MOS-2) and ESA (Meteosat, Sirio-2, ERS-1) programmes, in particular in the area of ocean monitoring in which only Japan and Europe (ESA) are now engaged. Japan plans to launch its first Marine Observation Satellite (MOS-1) in 1986 and the first ESA Remote Sensing Satellite is scheduled for launch in 1987. It was agreed that, owing to the similarity of the two programmes with regard to mission objectives and timescales, bilateral coordination will be intensified. In particular, both parties will establish their requirements for reciprocal acquisition of data.

The possibility of using the ESA transfer orbit network for supporting the early orbit phase of the Japanese MOS-1 satellite (telemetry and telecommand) was discussed.

Some information was also exchanged on the telecommunications programme.

KLEINKNECHT RETIRES

Kenneth Kleinknecht, one of NASA's most experienced engineers and managers left NASA on 2 October 1981 to work with Martin Marietta on the MX missile project.

Kleinknecht joined NACA's Lewis Research Center in Cleveland in 1942 after earning his bachelor's degree in mechanical engineering at Purdue University. In 1951 he transferred to the NACA Flight Research Center as aeronautical research scientist on the X-1, D-558 and the X-15 rocket research aircraft until 1959, when he joined the Space Task Group at NASA Langley Research Center. The Space Task Group evolved into the Manned Spacecraft Center, renamed as the Lyndon B. Johnson Space Center in 1973.

Kleinknecht was manager of Project Mercury, became deputy Gemini Program manager at the end of Mercury, and in 1967 was named Command and Service Module manager for Apollo. From 1970 to 1974, he was manager of the Skylab Program.

He became JSC Director of Flight Operations in 1974, and assistant manager of the Space Shuttle Orbiter Project in 1976. Kleinknecht spent two years as a NASA Headquarters representative to the European Space Agency (ESA) in Paris before returning to JSC as Orbiter 102 (Columbia) vehicle manager in charge of completion of Columbia's manufacture and thermal protection system (heatshield tiles) modifications prior to the successful first orbital test flight in April 1981.

NASA VISITOR CENTRE

The Visitor Center at NASA's Johnson Space Center in Texas was renamed as the Olin E. Teague Visitor Center last summer after the late Congressman who served on the House Committee on Science and Astronautics from 1959 to 1978.

The centre contains memorabilia and displays tracing the development of rocketry from its earliest origins in ancient China through to the work of rocket pioneer Dr. Robert Goddard and NASA's activities over the last 20 years. Lunar rocks, a full size lunar lander and the Apollo 17 command module are among the many items on display.

LASER DOCKINGS

Harry Erwin, a NASA microwave expert, raised a few eyebrows when he put in a request for a toy train set. It was all for a good purpose: he wanted to test a laser ranging system by mounting a reflector on the train to find its distance and speed. The results will go towards building laser-docking systems for spacecraft.

"Two parameters we must measure very accurately are velocity and distance at close range," said Erwin. "That rules out existing rendezvous radars which can track a target accurately at long distances, but lose it close in."

A typical radar picks up targets 300 miles out, tracking accurately to 300 ft, where another system must take over.

"It's the final closing 300 ft or so that needs a precise measuring system, one that accurately measures low speeds and distances. We think we can do it optically."

The search narrowed to a newly-marketed, low-powered diode laser system that sends light energy modulated with ranging tones. The light bounces off the reflector back to the laser's receiver where the computer processes and calculates the time it takes to make the round trip.

One of the first built, the laser diode, about the size of a grain of salt, converts electrons to photons, resulting in an infrared laser beam. The beam, about a millionth of a watt, is visible only through a special image converter.

The laser experiment was conducted in a blackened 15 ft diameter steel tunnel to model the lighting conditions that exist in space docking. Once the diode laser rendezvous and docking technique is perfected, a more powerful carbon dioxide laser beam will be installed to confirm the diode system's accuracy and help to set a standard.

If all goes well, the miniscule beam of light may guide hundreds of tons of metal to powder-puff-soft dockings in the blackness of space.

IN THE PAST

25 Years Ago ...
February-March 1957. Preparations were in hand at the Cape for the launch of the Vanguard test vehicle, TV-1. Numerous problems forced a postponement from the late February launch date to early May.

20 Years Ago ...
20 February 1962. John H. Glenn completes three revolutions of the Earth aboard *Friendship 7*, successfully completing America's first manned orbital mission. He was the third person to orbit the Earth.

15 Years Ago ...
10 March 1967. First flight Lunar Module, LM-1, completes an integrated test at its factory in Bethpage, New York three months before shipment to the Cape.

10 Years Ago ...
24 February 1972. Following cancellation earlier in the year of the proposed unmanned Grand Tour of the Solar System, NASA announced a revised plan to launch two unmanned Mariner-type spacecraft in 1977 on gravity-assist missions past Jupiter and Saturn. The Voyager project we know today was born.

5 Years Ago ...
6 March 1977. Japan becomes the third country to successfully place a satellite in a geostationary orbit. Engineering Test Satellite 2 was launched on 23 February and was positioned above Kawe Island, Indonesia.

D. J. SHAYLER

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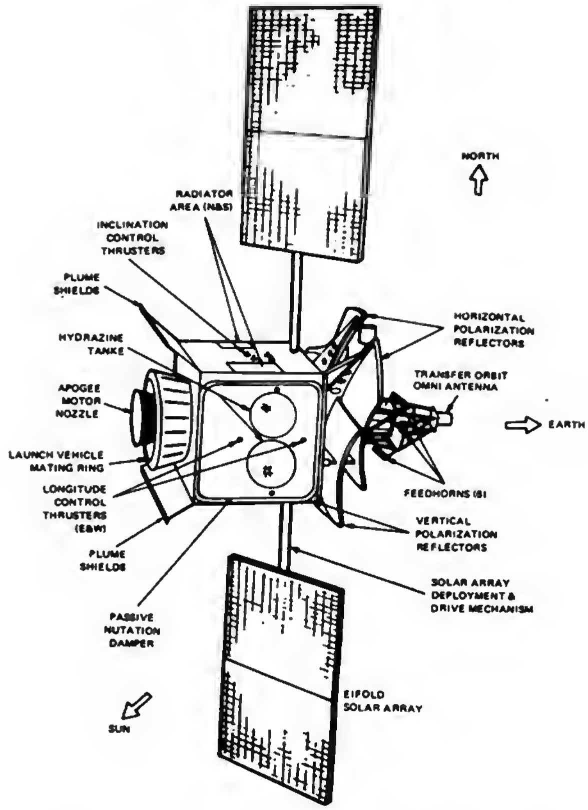
SPACE COMMUNICATIONS

SATCOM III-R LAUNCHED

The Satcom III-R satellite, intended for the distribution of video programming to cable TV systems throughout the United States, was launched by a Delta 3910 from Canaveral on 19 November.

Satcom III-R (called RCA-D before launch) joins two other RCA satellites, Satcoms I and II, in orbit since 1975 and 1976. The satellites provide coverage for all 50 states and Puerto Rico with television, voice channels and high speed data transmission. There are currently more than 4000 Earth stations with direct access to these spacecraft. The new 24 channel craft is designed to have a useful life of at least 10 years in its orbital slot at 132°W.



Above: main details of the Satcom III-R communications satellite. *Below:* artist's impression of the satellite deployed in orbit.

RCA

OTS TO THE RESCUE

On 11 November 1981, the main terrestrial PTT switching centre at Lyon in France was destroyed by fire. As a result, all national telephone and telex connections to and from Lyon were lost, together with international through-connections to Italy. The local telephone service in the Lyon area also ceased to operate.

Within hours of the emergency, a transportable 3 metre antenna Earth station was deployed at Lyon by the French Administration and 30 telephone channels for priority traffic were established between Lyon and Bercenay (near Paris) through ESA's, OTS satellite, launched in 1978.

MARITIME RESEARCH

Inmarsat, the International Maritime Satellite Organization, is funding a $1.5 million research and development project in maritime satellite communications, identifying areas for improvement and looking at new ideas.

Key areas for study include extension of all new telecommunications services available on land to mobile users, specific features required to support a new and vastly improved distress and safety communications system, a new ship terminal standard for users requiring several channels (e.g. in the off-shore industry) and concepts for next-generation Inmarsat satellites.

It will also include the study of characteristics of an Earth station mainly for telex and low-speed data applications suitable for very small ships. Such a terminal might also be of interest for other mobile uses such as on board aircraft.

In the context of the research and development programme, Inmarsat has decided to make space segment capacity available for experiments with communications for aircraft and land vehicles.

G STAR ANTENNAE

Spar Aerospace (the builders of the Remote Manipulator for the Shuttle) has been awarded a $7.4 million, 27 month contract for the design and construction of three antenna for RCA's Gstar communications satellites.

L-SAT

The British Government is contributing £77 million to the £230 million L-Sat communications satellite project. British Aerospace hold the prime contract, worth £150 million, with Italy acting as the other main partner.

The first L-Sat is scheduled for launch in 1986 by Ariane and will provide direct communication links to small dish aerials across Europe.

TRAINING FOR SPACE

By G. L. Borrowman

In the past, astronauts have been highly-trained pilots or scientists with very special qualifications. The advent of the Space Shuttle will change that. We will soon see scientists and engineers going into space without piloting skills and, in the more distant future, passengers with minimal qualifications by present standards.

Introduction

At the conclusion of the successful 139 day Soyuz 39 mission, flight director Alexei Yeliseyev asserted that the only barriers to long-duration spaceflight are psychological.

Socio/psychological factors become of paramount importance on long duration missions; particularly with mixed-sex and-nationality crews.

For the short-term, the selection of women as crewmembers for Shuttle and Spacelab missions will occur over the next decade.

In addition, Spacelab crews will be more heterogeneous because on many flights there will be three categories of crewmembers. The basic crew for a mission includes a commander, a pilot and a mission specialist. Normally, this crew complement can accomplish any duties associated with a flight. Should any payload activity require specialised talent not available within the basic crew complement an individual can be flown to accomplish this specialised activity. Such an individual is referred to as a payload specialist and would be proficient in his unique talent. He would not require training to accomplish the payload activity as he or she would already have these talents. The payload specialist would receive training relating to living and working in space and would be trained in any emergency procedures.

Very recently the European Space Agency took advantage of the opportunity to train individuals as mission specialists on a reimbursable basis. A similar offer was made to the Canadian Government on 13 August 1979.

According to Dr. Ken Money, of the Defence and Civil Institute of Environmental Medicine of Toronto:

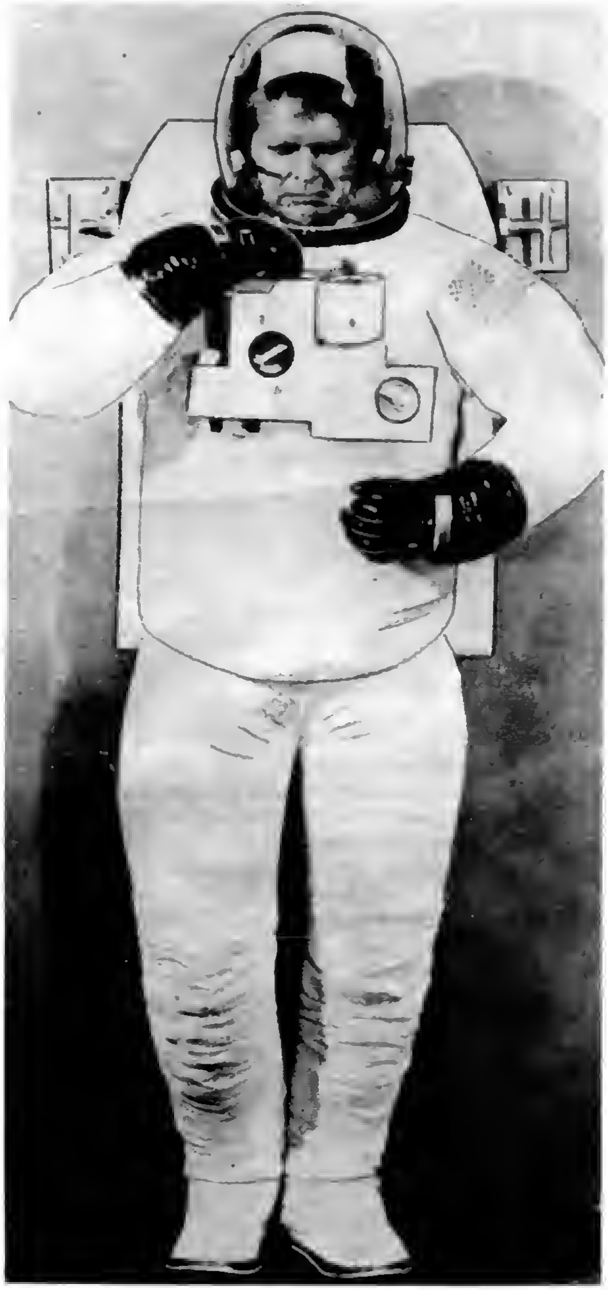
> *"I have recently been told that NASA policy with respect to training mission specialists is changing in favour of training mission specialists to do the scientists' jobs in space, and thus makes my chances of personally flying in space seem quite remote. It is possible that this policy will change again, especially if a serious persistent motion sickness problem plagues the STS (Space Transportation System)"[1].*

American space missions have to date been conducted with a vertical, military command structure. The spacecraft Command Pilot is responsible for all procedural and crew behaviour, and he is under the direct command of Mission Control. Overall control of flight plans and activities rests in the Mission Operations Control Room at the Johnson Space Center.

This hierarchical chain of command has been successful as the overwhelming majority of astronauts were members of the military. Also, the NASA organisational structure under the astronauts has undergone lengthy training which is also hierarchical in nature.

The Shuttle commander will be authorised to enforce order and discipline during all phases of an STS mission. This authority includes any and all persons on board the craft, and Spacelab.

A Spacelab mission involves the use of a complex organisational structure. The overall mission will be the responsibility of an astronaut trained and under the command of the Astronaut Office. However, the scientific objectives of the mission will be controlled by a Mission Specialist. The scientific objectives will be set by Principal Investigators who will have expectations of exerting influence and control over the operation of their experiments and flight operations that significantly impact experiment results.



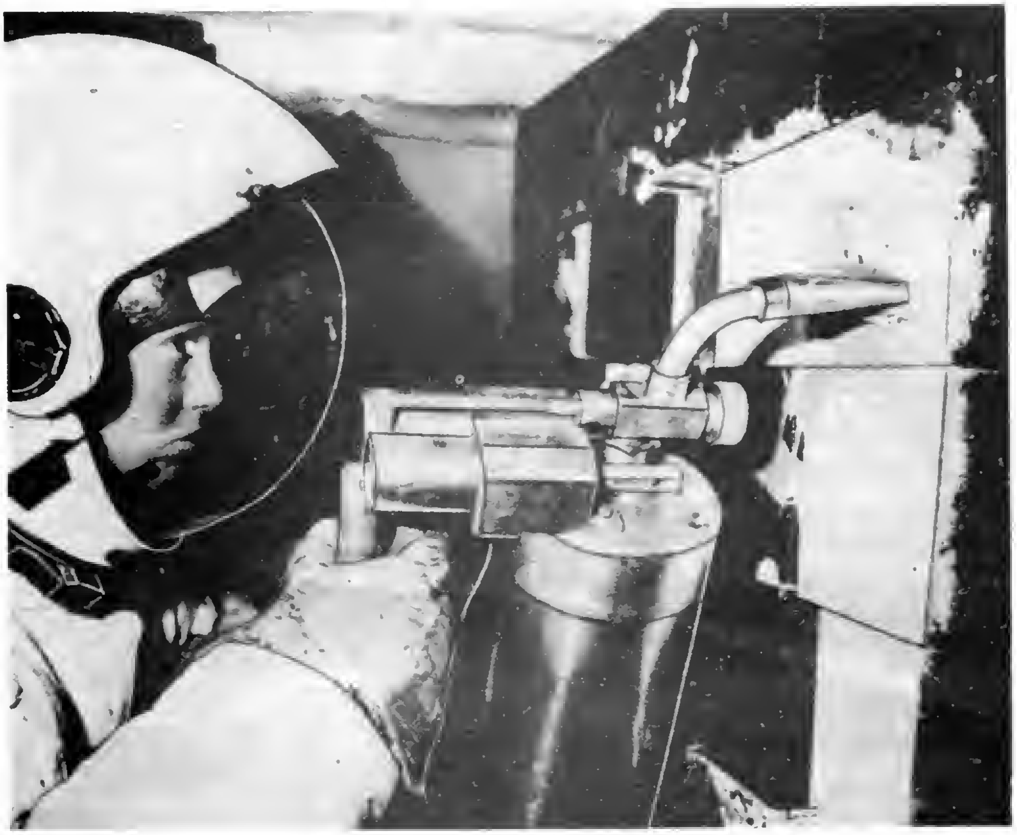
The Shuttle EVA spacesuit. Mission specialists are trained to use the suits but payload specialists are not – it is their job to look after the specialised experiments.

NASA

Such a set-up will require a strong centralised command structure to ensure mission safety and an adequate ability to respond to emergency situations.

The Soviet experience

The Salyut 6 space station has the manned record for a



Mission specialist Anna Fisher practises the repair of thermal tiles on a Shuttle EVA.

NASA

single crew (185 days). In such close quarters, the Soviets have hosted visiting crews at various intervals for periods of about a week. In moving from the experimental to the operational phase of manned space flight operations, the Soviet Union has placed great emphasis on the psychological compatibility of cosmonaut crews. In a paper prepared by Academician Oleg Gazenko, director of the Soviet Institute of Medical and Biological Problems, the Soviet approach to psychological compatibility was contrasted with that of the US.

"... The Soviet Union attaches great significance to psycho-physiological factors. While recognising the significance of the social factors, Soviet scientists believe, at the same time, that in conditions of close space aboard an orbital station or a spaceship that the psycho-physiological traits of a cosmonaut, his individual resistance to stress and tensions, come to the forefront."

The isolated seaborne expeditions of Thor Heyerdahl served to confirm Gazenko's view that "diplomatic relations" are not as important as individual personality traits. The result of this effort is currently an attempt to set down guidelines for selection of flight crews.

"Special tests have been developed which help to establish the psychological compatibility of cosmonauts," said Gazenko. "Members of the future crew are asked to take different tests. In these, scientists try to model interdependent activities of a cooperative or competitive character. During these experiments and tests we often meet with cases when the partners compete with each other, each claiming his right to leadership, even when the test suggested cooperative types of activities. And vice versa, the partners well-disposed towards each other form a team in a situation demanding competition."

One index derived by the Soviet researchers is that of the coefficient of pulse beat coincidences. The higher the coefficient, the better the cooperation of cosmonauts in space[2].

With the exception of Skylab, Soviet and American spacecraft have had very limited living space. A three-man crew remained aloft in Skylab's 350 m^3 for 84 days. A Salyut 6 crew remained in orbit for 185 days. Salyut 6 provided 71.5 m^3. In this confined volume the cosmonauts periodically hosted teams of Interkosmonauts.

The long-duration missions aboard the Salyut space stations placed great emphasis upon the problems of space psychology. Soviet investigators are currently grappling with the problems confronting cosmonauts living and working in space for periods of up to 6 months.

From a study of the data from the Soyuz 17 30-day mission and the Soyuz 26 96-day mission, functional disorders, caused by an over-arranged environment, enhanced adverse effects of weightlessness (*viz.* haemodynamic, vestibulo-vegetative, biochemical and other disorders), are revealed.

The cosmonauts were confronted with the paradoxical situation of abiding by the dictates of a time-line which prescribes tasks that overload the cosmonauts and their ability to successfully complete the tasks. Thus crewmembers in future will be given more freedom in setting their tasks.

The confinement in orbit for a protracted period of time in a volume similar to a holiday caravan demands that the crewmembers' contacts be enlarged as a mode of social activation.

The Salyut 6 crewmembers were given psychological support (individual-personality, socio psychological and emotional aspects) through the use of a videotape (videotheque) containing 58 concert programs (10 of which had been prepared by specialists from Czechoslovakia, Poland, and East Germany).

Women in space

General Andrian Nikolayev in an interview with Peter Smolders commented on the role of women in space.

"As far as difficulties are concerned, women can endure more than men. Our women can do the same as men. But at the moment we have no women in training at Zvyozdny Gorodok.

"First of all because the kind of work is very tough. When

Training for Space/contd.

at the beginning of the 'sixties, we made our first flights, the man or woman aboard the spacecraft only had to be a pilot - not less but not more either.

"At present the accent is primarily on useful scientific work and the cosmonaut has to be a one time pilot, a commander, an engineer and a scientist. For instance, he has to know a lot about astronomy, geology and meteorology. He must be able to evaluate what he sees through the portholes.

"Of course, a woman can possess all these qualities, but the mission programme makes big demands on her, especially if she is married. So nowadays we keep our women here on Earth. We love our women very much; we spare them as much as possible.

"However, in the future they will surely work on board space stations, but as specialists - as doctors, as geologists, as astronomers - and, of course, as stewardesses"[3].

One of the more dramatic innovations in American space flights of the 1980's will be the presence of women. The Shuttle opens the new era of routine journeys into Earth orbit.

The presence of female mission specialists has caused a great deal of interest in the training programme. Dr. Judy Resnik has described the attitudes confronting her and the training regime designed to prepare them for orbital operations.

"Most of what we do is ... go to meetings and go to classes and just regular old normal stuff ..."

"The physical aspect of the training places emphasis on giving the trainees the knowledge and capability of taking care of themselves in emergency flight situations. Training of the newly-selected female astronaut candidates has been no different from that which the males have received, including various classroom courses and briefings, jet (aircraft) familiarisation, survival training, parasail training and zero-g parabolic flight sessions.

"Mission specialists are flying in the backseat of the T-38; it's a two-seat aircraft. We have been training ... on flight-planning, communications and navigation. And we do get to do some flying. This helps us become better crewmembers; to be able to coordinate with the pilots; to be able to speak effectively over the radios which is something that we will be doing with communicating back to the ground. It also gives us the opportunity to experience some of the manoeuvres and to get familiar with zero-gravity pulling 'g's' as they say ...

"They also taught us how to, in a simulator, get out of the plane on the ground if there is an emergency. It's a simulator of a T-38. And you get all strapped up and they say 'go'. And you unhook all your equipment and go and see how fast you can get out if you have a ground emergency."

"As spacecraft habitability and man/systems integration is critical to mission success so the anthropometric and physiological differences between males and females assume great importance.

" ... modifications to the Orbiter's facilities involves the location of flight deck seating during launch and entry phases. Original plans called for adjustable pilot seats which accommodate the Commander and the Pilot, in more or less, standard cockpit fashion. And a fixed-location for the Mission Specialist seat which occupies a second row behind the pilot seat for ascent and re-entry phases of the flight, also facing forward. We went through a reach limit exercise in the fixed third seat since it is necessary for the Mission Specialist to access panel switches, and so forth, while strapped in the seat.

"Obviously a 5 ft 2 in woman with short arms and a 6 ft 4 in man built like an ox have different reach limits. And low and behold, short people could not reach the necessary switches. A seat modification is now in work to allow all crewpeople to reach the appropriate hardware.

"Now is probably a good time to introduce to you the concept of the modular astronaut by mentioning that this seat position is now required to accommodate the entire range of a fifth percentile female to a 95th percentile male ...

"... It would seem that the freedom of weightlessness would remove any inadvertently built-in bias against short people as far as equipment layout is concerned. However, in an effort to provide more Earth-like conditions for crew operations on orbit, NASA has devised suction-cup shoes to allow a firm anchor to the deck so that the lower-half of one's body doesn't flail around needlessly. Such a device was loudly applauded until we short people arrived on the scene and realised that we weren't high enough to see out of the viewing windows of the Orbiter aft flight deck while we were thusly anchored. The equipment designers teased us a lot about having to make high-heeled shoes with suction-cups and about short people

Mission specialists David Walker and Anna Fisher. Both will probably make their first flights into space this decade.

NASA

Part of NASA's Group 9 pilot and mission specialist astronauts. Front, left to right: Nicollier & Ockels (European candidates), Richards, Spring, Bridges, Hilmers and Bolden. Rear, l. to r.: Springer, Smith, Lounge, Dunbar, Ross, Cleave, Chang, Blaha, Fisher, Bagian and O'Connor.

NASA

having no reason, et cetera.

"But instead they're making stools with suction cups on which we can suction-cup our one-size fits-all unisex shoes."

Female body measurements are especially important to consider in the design of the Space Shuttle pressure suit, which has a hard upper torso (HUT) and is to be pressurised in standard sizes to fit both sexes.

"Some equipment problems have arisen from our different size and shape. Once again, let me refer to the mythical modular-size astronaut.

"I'd like to first mention the classical space suit because the total number of astronauts is growing in expectation of frequent, routine Space Shuttle flight in Earth orbit. The past tradition of individual custom-fitted suits for each astronaut is no longer practical nor economical. NASA's transitioning to a design concept of proportioning a medium-sized suit, for example, to a fiftieth percentile female. And scaling dimensions up or down to accommodate large or small size respectively.

"The original thought was that most of the women would fit into the men's small size suit. It turned out to be somewhat true. All of us could fit in the same suit at the same time. So NASA agreed to the manufacture of an extra small size suit which was again scaled-down accordingly from the standard of the fiftieth percentile male proportions. Unfortunately, the designers overlooked the fundamental axiom that female astronauts are generally broad where they should be broad, generally. Which is luckily not in the same anatomical hemisphere where male astronauts are broad. We really stressed the one-size-fits-all theory. A suit scaled-down proportionately to fit snugly around the chest of a fiftieth percentile female had the minor problem that one could not get one's head through. But the size was adjustable proportionately so that heads could squeeze through the suit's shoulders and reached the occupant's elbows. That either says something about the collective head sizes or the collective chest size of the women astronauts.

"It got to the point where I was no longer 'Judy' to the suit technicians. I had become fifth percentile chest with ninety-fifth percentile elbows.

"Speaking of pressure suits, one of the more delicate problems of wearing one for several hours is how to accommodate nature calling. Let me say, 'There is no dignified way for either gender ...' Let me tastefully try to satisfy your curiosity on this subject by describing the current solution. And I stress current and not final for female astronauts as developed by NASA.

"In the truest sense of NASA-ese, the device has an acronym. It's called the DACT - Disposable Absorbent Collection Trunks ... more affectionately known as the 'diaper'. The garment can most graphically be described as a combination long-legged panty-girdle moulded with super-size Pampers. I am convinced that it is the most uncomfortable contraption ever designed for womankind. One feels as if she is walking around straddling a horse. And if it is not bad enough having such accommodations available during space flight, we also have to practise beforehand. Over and over until we get it right, I guess.

"Further notable personal equipment problems have also surfaced in at least two other areas so far. For one, it was found that standard parachute harness tightened to their maximum were not sufficiently snug to prevent small shoulders from sliding right out. Which doesn't help you much when you're trying to survive. Additional padding and cross-strapping had to be added to provide adequate protection.

"Also, Orbiter oxygen masks, even the smallest manufactured, were not properly proportioned for the narrower facial structure of a woman and provide a tight enough seal. That also had to be redesigned. And I might add that NASA has been more than prompt and thorough in correcting such deficiencies, most of which were never really anticipated ahead of time.

"On a lighter note, in regards to on-orbit supplies ... we also discovered that previous astronauts had basically slept in their knickers or less during their missions. NASA had somehow assumed that this practice would continue in the Shuttle era. To preserve a shred of decency in mixed flights, at least publicly, the women queried if there were any T-shirts available in stock to use as pyjama tops. Believe it or not, NASA had not budgeted for required clothing. NASA also caved in to our desire for a deodorant selection other than Old Spice or English Leather and has swallowed the weight penalty associated with one container each of wrinkle-cream and a tube of lipstick"[4].

REFERENCES

1. Personal correspondence, Ken E. Money, Senior Scientist Defence and Civil Institute of Environmental Medicine, 25 Mar 1980.
2. *Soviet Aerospace*, 10 Mar 1980, pp. 75-76.
3. *Spaceflight*, 19, Sep 1976, pp. 334-335.
4. "Women In Spaceflight: A New Perspective", presented by Judith A. Resnik to the 14th Annual Reunion of the Missile, Space and Range Pioneers, 2 May 1980. Transcript prepared by the author.

PERCHERON — A SPACE WORKHORSE

Paul D. Maley*

Introduction

Non-government sponsored space programmes have been few and far between. Efforts such as that by the California rocket pioneer Robert Truax have yet to bear fruit but have stimulated the interest of others into trying to construct rocket carriers capable of reaching suborbital and orbital heights.

Space Services, Incorporated (SSI) of Houston is one organisation of entrepeneurs which plans to compete with the major commercial payload carriers, (the American Space Shuttle and Delta, and the European Ariane). Its vehicle programme centres about a rocket module similar in size to the Redstone that would be mass produced using low cost, high technology techniques, with only modular variations being required to produce different orbital configurations.

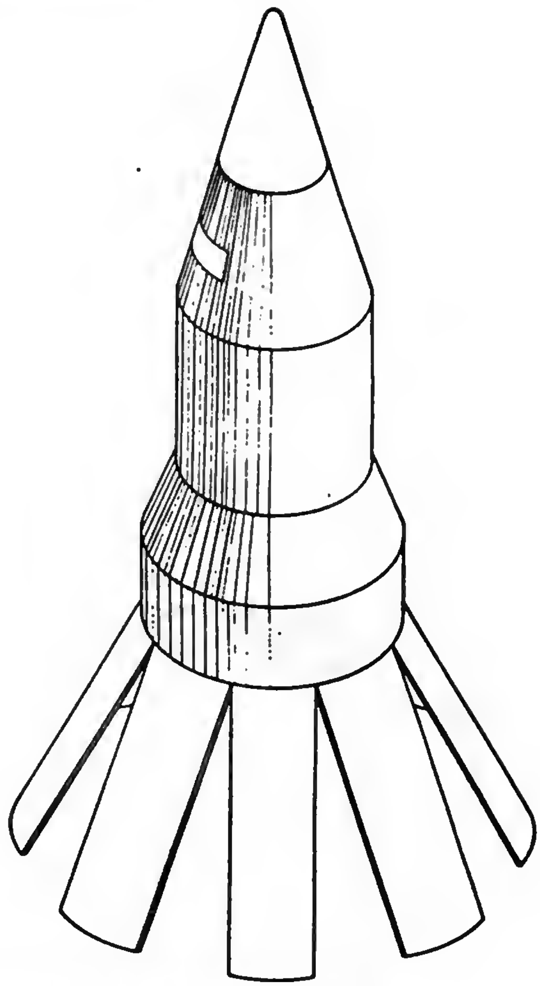
The Vehicle

The SSI vehicle is known as Percheron (after the French for work-horse). It is 1.2 m in diameter and almost 14 m tall; the addition of a nose cone and engine brings the final length to over 17 m. The pressure-fed engine has a potential thrust of 34,000 kgf, although the first prototype reached only 27,000, and uses a coaxial pintle system like that on expendable launch vehicles and in the Apollo lunar module descent engine system. This particular engine burns JP-4 kerosene as fuel with liquid oxygen as an oxidizer.

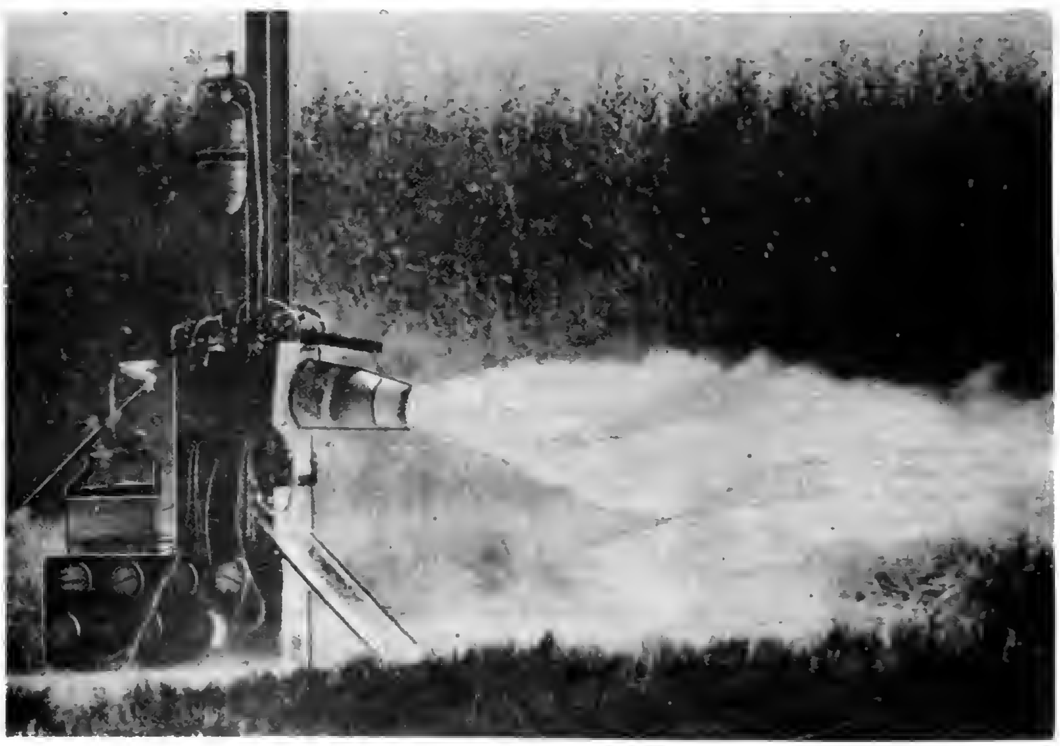
A gas pressurisation system is mounted on the nose to maintain tank feed pressure at 350 psi for both the kerosene and the oxidizer. A common bulkhead separates. fuel and oxidizer; it was the bulkhead which separated during the August 1981 catastrophe when the first rocket was destroyed during a static test. No gimballing of the engine is permitted but a smaller thrust control system provides attitude control.

A 4 m long payload section in the shape of a truncated cone and capable of surviving reentry is carried. A number of

*Ford Aerospace and Communication Corp.

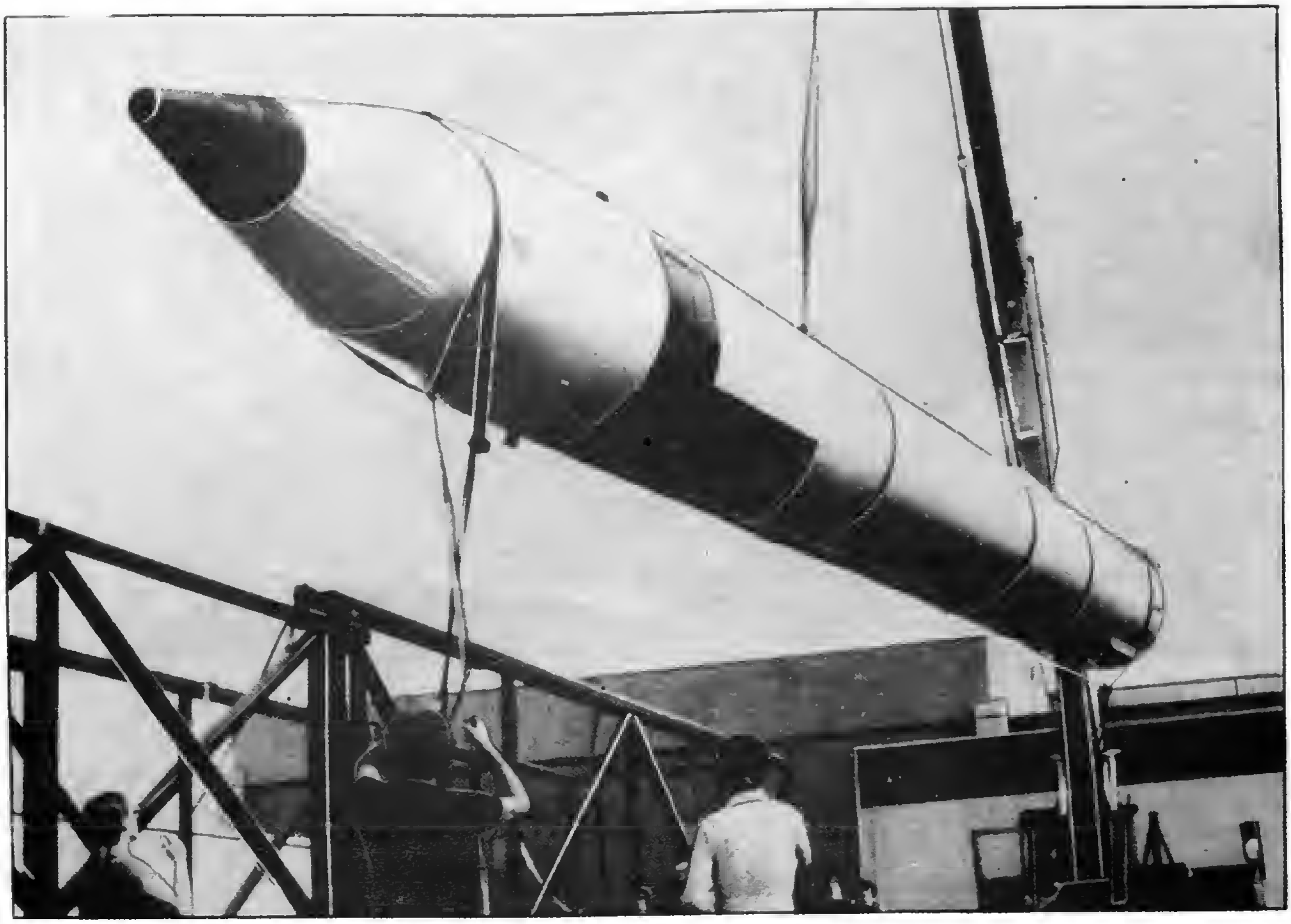


Percheron payload segment with extended vanes.



Static engine firing in California, 1981.

All pictures courtesy of SSI



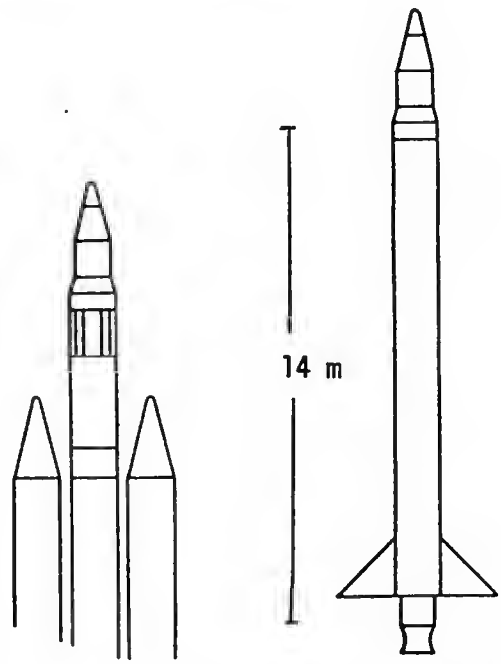
The Percheron prototype being loaded into a trailer for transport to the Texas test site. A static engine firing in August last year destroyed the vehicle.

expandable vanes lie at the rear to help to orient the capsule at the proper entry angle, thus controlling the rate of descent and downtrack/crosstrack imbalance. Parachutes, the reaction control subsystem for on-orbit adjustment and an avionics bay make up the remainder of the segment.

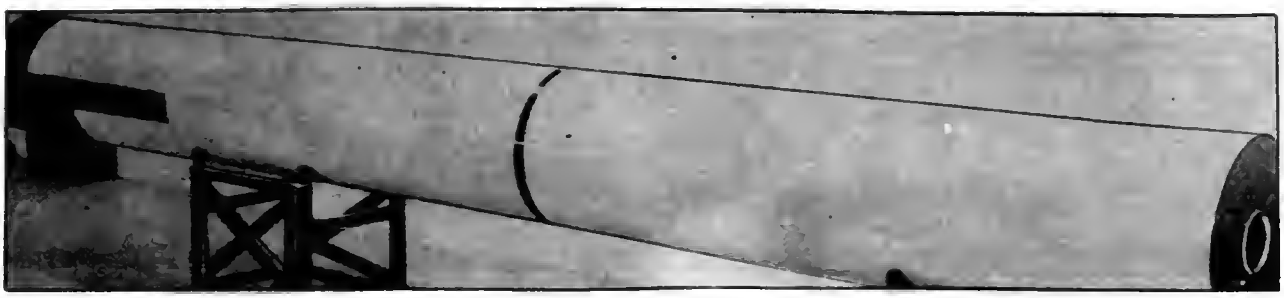
Other versions could be created by adding to this basic production model: a production model plus upper stage, and a production model/upper stage with strapon boosters. The upper stage could be either liquid or solid fuelled. Parallel staging (as in the Space Shuttle) occurs in the third version when two or more strapons plus the main engine fire simultaneously to increase the overall boost altitude prior to upper stage burn towards geosynchronous orbit. For a heavy payload, a cluster of seven modules is linked together; the outer six fire until four are depleted. These four are jettisoned and the remaining three fire together.

For the past 25 years the major space countries have used a wide range of rockets to boost payloads into space. Each of these countries' programmes is weighed down with the encumbrances of government bureaucracies. SSI's development efforts have concentrated on using rented launch sites, (eventual) rented tracking stations, minimal support facilities, in-house consulting and the construction of partially reusable rocket components in order to minimise lengthy qualification and test cycles.

Percheron's body is formed of a glass filament-wound fibre mainly because of the optimal weight and cost advantage. Use of aluminium and stainless steel is provided for in the various equipment support structures. Purchase of filament winding equipment is expected to comprise a principal expenditure for SSI's production facility.



The Percheron module prototype (right). Later versions could carry an upper stage and boosters attached to the side of the main stage (left), similar to the much larger Titan III. The first test flight of the second prototype is not expected until this summer at the earliest.



The main body of the Percheron prototype.

The SSI programme plans to run at a per flight cost of one-third that charged by NASA for a user contracted to fly on the Space Shuttle. In order to achieve this, the following techniques are employed:

1. Use of identical production engine modules
2. Cluster small systems rather than building large heavy lift single engines
3. Use of pressure-fed instead of pump-fed fuel systems
4. Use of low cost and easily obtainable fuel
5. Use of lightweight structural material
6. Use of recoverable payload sections
7. Use of "off the shelf" technology rather than existing military-grade equipment
8. Minimise programme management and personnel costs
9. Contracting with existing ground stations for data link rental

The cost for a payload to fly on any commercial space transportation system depends on the success, launch rate, actual costs versus programmed profit margins and other variables. User charges for the Delta are at $22 million in 1981, rising to $25 million by 1984, while cost to a user of an entire Space Shuttle payload bay in 1982 is to be about $35 million, moving upward to $50 million by 1985. Since the Shuttle may carry up to four payloads in its cargo space, the bill per payload, depending on the services involved, can become evenly divided out among multiple users.

Ariane has a similar cost structure in its pricing scheme. Arianespace is presently charging $21–26 million for Delta class launch capability (900 to 1400 kg payload) with the expected cost per kilogram on-orbit forecasted to drop significantly in the later 1980's.

SSI computes its user fares at $5 million beginning in 1983, providing it succeeds at its expected levels and achievements of launch. If this figure is indeed realistic and the Percheron test programme and development phases go smoothly, the SSI vehicle might provide a competitive service for payloads whose own budgets would not allow the higher charges incurred by Shuttle and Ariane. It would also provide an alternative for the backlog of users who prefer not to wait a protracted period of time to find a slot on the major launch systems.

Space Services' budget does not permit massive expenditures on launch sites, so for its first test a 3000 acre area was leased on Matagorda Island located off the southern Texas coast at latitude 27.9° North and longitude 97° West. Ironically, the island is in the same locale that NASA was considering 20 years ago as its prime candidate for a southern launch site. Cape Canaveral was later selected.

Following the August 1981 setback, Space Services planned to rebuild in California, estimating only six months completion time for the second model. Qualifying the propulsion system seems to be the major problem; its schedule showed about 200 test firings.

SSI's move is to capture a portion of the lucrative geosynchronous satellite market that already totals around $1,000 million, as well as to provide boost capability for small scale laboratories, zero-G experiments, and small scientific payloads. Creation of the joint corporate effort was partially the result of encouraging studies published by the American Institute of Aeronautics and Astronautics, revealing that user demand in the years prior to 1990 might fall short of the Space Shuttle's abilities to deliver all of the prospective customers' payloads into orbit.

An orbital test launch was planned for early 1983 and preliminary talks have already taken place with the US Air Force with the intention of using Vandenberg Air Force Base in California for possible polar low Earth orbit missions, with future thoughts of lifting up to 2300 kg payloads. There are no intentions of launching any manned missions.

CONESTOGA

Since this article was written, SSI have extensively revised their plans, writes Paul Maley. The company has made a formal decision to switch to a multi-stage solid rocket to be designated the "Conestoga" (after the wagon train concept used in America's early frontier days). Space Vector Corporation of Northridge, California, has been selected as the principal company to actually build the vehicle because of their experience in constructing solid sounding rockets at the White Sands Missile Range in New Mexico. Eagle Engineering of Houston, founded by Hugh Davis (formerly of NASA), will provide launch design facilities and integration for SSI.

The original investors are still backing SSI, even after the explosion. It was noted that the whole project would cost much less than the price tag of one oil rig with significantly higher potential. The budget for the next launch is about US$2 million, double that of the initial Percheron firing. If the solids prove themselves, SSI sees itself to become profitable no earlier than the end of 1984 or the beginning of 1985.

A low Earth orbit goal of 11,000 kg and geosynchronous payload of 2,200 kg are the new targets.

Liquid fuelled rockets are still on the drawing board for SSI's future, but it is unclear as to whether any development will proceed before profitably occurs. The first solid rocket liftoff test flight will be from the original site at Matagorda Island. A 250 mile downrange flight is planned. A follow-up launch providing the first is successful would be an orbital test also sent up from Matagorda. Since SSI's payload planning centres about Earth-sensing satellites which require Sun-synchronous orbits, operational launches are expected to take place elsewhere. The southern end of the island of Hawaii is one location that SSI is scouting.

NEXT MONTH

April's *Spaceflight* will feature articles on ESA's Hipparcos and Kepler proposals, manufacturing on the Moon, the USAF Test Pilot School, and the latest Salyut 6 mission report.

SATELLITE DIGEST - 152

Robert D. Christy
Continued from the February issue

A monthly listing of satellite and spacecraft launches, compiled from open sources.

The heading to each launch gives the name of the satellite, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes except where marked with an asterisk, where the time is to the nearest minute as announced by the launching agency

COSMOS 1306 1981-89A, 12828

Launched: 2030, 14 Sep 1981 from Tyuratam by F vehicle.
Spacecraft data: No details available, but may be several tonnes mass.
Mission: Probably an ocean surveillance satellite carrying out electronic reconnaissance, working in conjunction with Cosmos 1286 (1981-72A), and replacing Cosmos 1260 (1981-28A).
Orbit: Initially 171×424 km, 90.49 min, 64.96 degrees, possibly resulting from a launch vehicle malfunction. Subsequent manoeuvres over a period of eight days resulted in the craft reaching its operational orbit of 430×442 km, 93.31 min, 64.94 degrees. An onboard, low thrust motor ensures a constant positional relationship with respect to Cosmos 1286.

COSMOS 1307 1981-90A, 12830

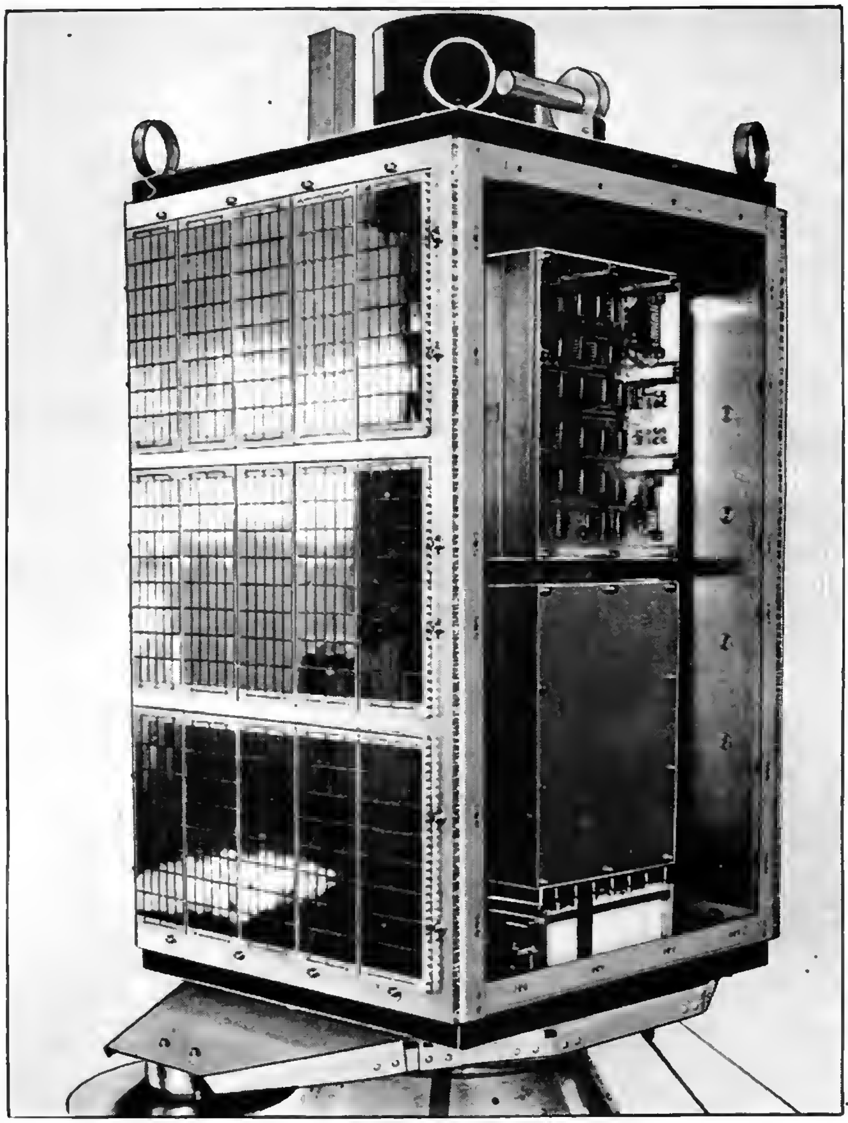
Launched: 1129, 15 Sep 1981 from Plesetsk by A-2.
Spacecraft data: Possibily based on Vostok manned spacecraft with spherical re-entry module, instrument unit and a cylindrical, supplementary payload at the forward end. Length about 6m, maximum diameter about 2.4m and mass around 6000 kg.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: Initially 196×393 km, 90.45 minutes, 72.89 degrees. Manoeuvred by the end of the second day to an operational orbit of 354×417 km, 92.29 min, 72.87 degrees, in which it was maintained by small thrusts to ensure constant spacing between equivalent ground tracks on successive days

COSMOS 1308 1981-91A, 12835

Launched: 0334, 18 Sep 1981 from Plesetsk by C-1.
Spacecraft data: Cylindrical body with domed ends, enclosed in a drum shaped solar array, with length and diameter both about 2m. The mass may be around 700 kg.
Mission: Navigation satellite replacing or backing up Cosmos 1275 (1981-53A).
Orbit: 968×1003 km, 104.85 min, 82.92 degrees.

COSMOS 1309 1981-92A, 12837

Launched: 0930, 18 Sep 1981 from Plesetsk by A-2.
Spacecraft data: Possibly based on Vostok manned spacecraft with spherical re-entry module and instrument unit. Length about 5m, maximum diameter about 2.4m and mass around 5500 kg.
Mission: Military photo-reconnaissance, recovered after 13 days.
Orbit: 211×256 km, 89.21 min, 82.30 degrees at launch which decayed to 196×224 km, 88.74 min just before recovery.



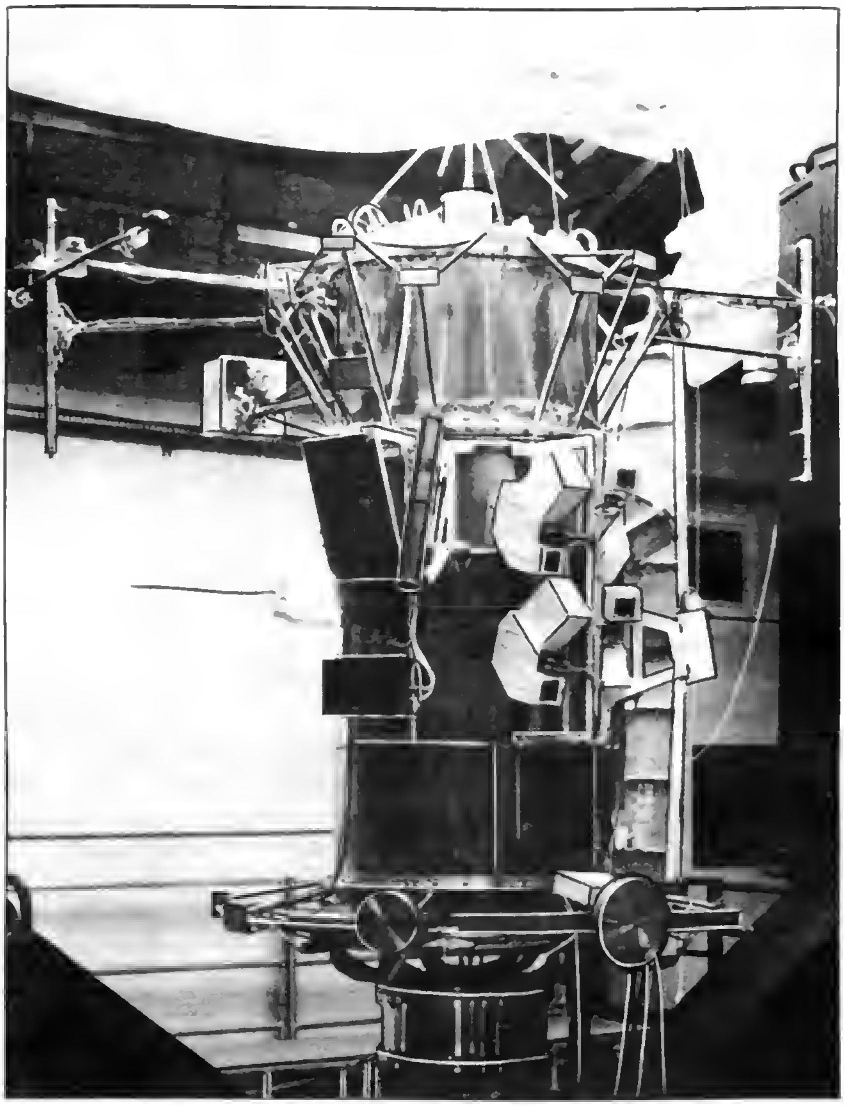
The UOSAT amateur satellite, launched on 6 October 1981 with the Solar Mesosphere Explorer.
University of Surrey

CHINA 9 (3 payloads) 1981-93B, D&A, 12483, 12485, 12482

Launched: 2132, 19 Sep 1981 from Shuang Cheng Tse.
Spacecraft data: The main satellite is an octahedral prism, 1m high and maximum diameter 1.2m. Electrical power is provided by four rectangular solar panels at one end. The second satellite takes the form of a cone, and the third was a balloon linked to a metal ball by a wire (it has decayed).
Mission: Space Physics experiments including studies of magnetic fields, infra-red and ultra-violet radiation, charged particle measurements, x-ray detection and atmospheric density. The latter was the function of the balloon which decayed after six days.
Orbits: All three satellites achieved orbits of about 390×1600 km, 103.3 mins, 59.4 degrees.

AUREOLE 3 1981-94A, 12848

Launched: 1309, 21 Sep 1981 from Plesetsk by F vehicle.
Spacecraft data: Standard Soviet Automatic Unified Orbital Station (AUOS) consisting of a cylinder about 2.5m long and 1m diameter (maximum) with electrical power provided by 8 solar panels each about 2.5m long, 0.5m wide. The mass is 1000 kg, including 170 kg of experiments
Mission: Ionospheric and magnetospheric



Aureole 3 undergoing testing at the Toulouse space centre operated by the French space agency, CNES. The body is a standard Soviet design with instruments mounted on the outside and the ends. One of the eight solar panels is attached at the right on the far side of the vehicle.

CNES

studies using Soviet and French-built equipment. Onboard sensors include spectrometers for studying protons and electrons, an energetic particles detector, an ion spectrometer, a hot ion mass spectrometer, a plasma interferometer, an electric field instrument, a magnetometer and a number of photometers.
Orbit: 404×1999 km, 109.48 mins, 82.50 degrees.

COSMOS 1310 1981-95A, 12852

Launched: 0801, 23 Sep 1981 from Plesetsk by C-1.
Spacecraft data: Not available, the mass may be around 1000 kg.
Mission: Possibly a military test vehicle.
Orbit: 476×517 km, 94.56 min, 65.83 degrees.

SBS 2 1981-96A, 12855

Launched: 2309*, 24 Sep 1981 from the Eastern Space and Missile Centre by Delta 3910, using a PAM-D 3rd stage.
Spacecraft data: Cylindrical structure covered in solar cells, 2.16m in diameter and 2.82m high in the stowed position. An extending, cylindrical solarcell panel which was deployed after launch increased the length to 6.60m. Built by the Hughes Aircraft Company to an 'off the peg' design, the satellite is spin stabilised with a de-spun aerial array. The orbiting mass is 550 kg.
Mission: To provide commercial communications through a network operated by Satellite Business Systems. The SBS system is the first to commercially use the 12-14 GHz band. The satellite contains an all digital relay system using 10 transponders capable of relaying up to 480 million data bits per second. It carries telephone, computer, electronic mail and video communications for business and industrial clients.
Orbit: Placed into a geostationary transfer orbit by the launch vehicle and injected into a geostationary drift orbit by an inboard apogee motor. It was later stabilised at its operating location, 97 degrees west longitude.

COSMOS 1311 1981-97A, 12871

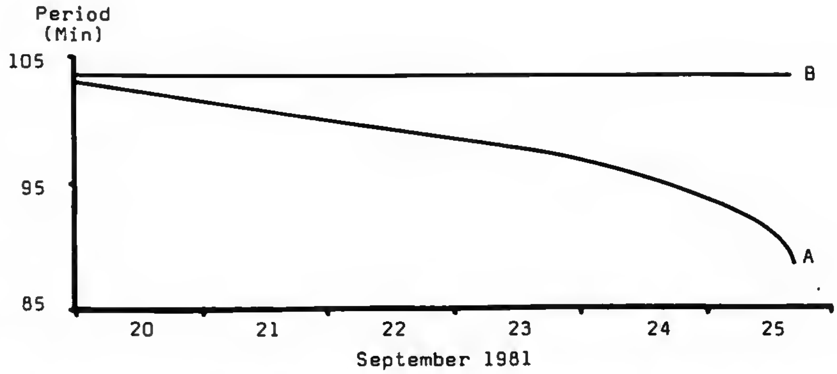
Launched: 2101, 28 Sep 1981 from Plesestk by C-1.
Spacecraft data: May be similar to the navigation satellites (see Cosmos 1308).
Mission: Not known but probably military.
Orbit: 465×557 km, 94.47 min, 82.95 degrees.

COSMOS 1312 1981-98A, 12879

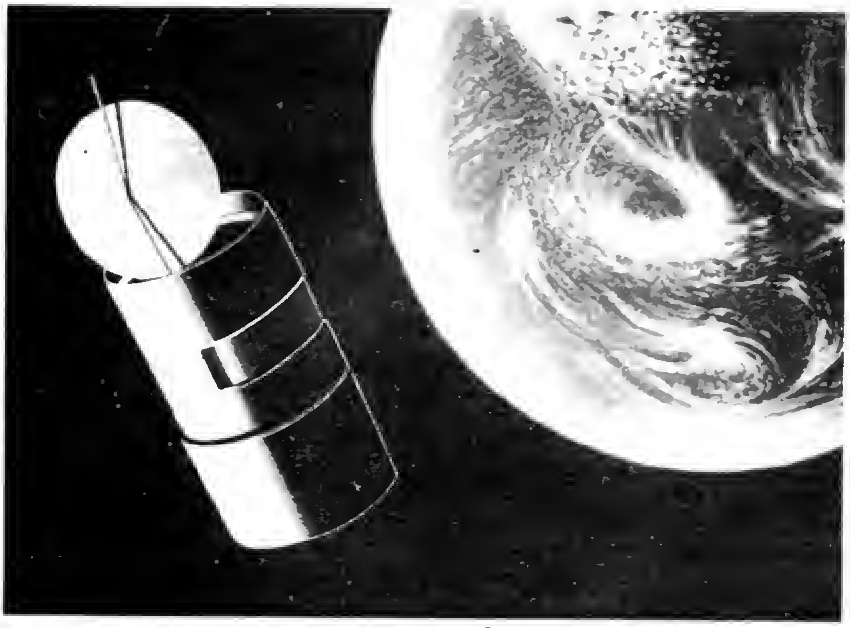
Launched: 0803, 30 Sep 1981 from Plesetsk by F vehicle.
Spacecraft data: Not available.
Mission: Not announced but may be geodetic.
Orbit: 1492×1503 km, 115.98 min, 82.59 degrees.

COSMOS 1313 1981-99A, 12881

Launched: 0859, 1 Oct 1981 from Tyuratam by A-2.
Spacecraft data: As Cosmos 1307.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 231×279 km, 89.64 min, 70.36 degrees with a manoeuvre on 9 Oct to counteract decay.



The two curves demonstrate the decay from orbit of the balloon satellite which was one of the China 9 payloads. Curve A is the satellite's orbital period over the six days it remained in orbit, dropping rapidly because of the air drag. Curve B represents the orbital period of the other payloads over the same six days; they were expected to remain in orbit for several months.



The Hughes Aircraft Company's HS 376 satellite, of which SBS 2 (1981-96A) is an example. The telescoping solar panel and folding aerial system makes it a compact vehicle, designed to fit in the Shuttle's cargo bay.

Hughes Aircraft Company

SOLAR MESOSPHERE EXPLORER 1981-100A, 12887

Launched: 1127*, 6 Oct 1981 from the Western Space and Missile Centre by Delta.
Spacecraft data: Cylinder, 1.7m long and 1.25m diameter with a 2.2m diameter disk shaped solar array fixed to one face. The mass is 437 kg.
Mission: To study the Earth's atmosphere at heights between 20 and 80 km. Specific areas of interest are the formation of ozone in a layer 30 km high, changes in ozone distribution resulting from solar radiation, ozone density changes and their causes, the relationship between solar radiation and physical atmospheric parameters and processes, whether a relationship exists between solar radiation and ozone occurrence, and to determine other causes of ozone changes. Onboard instruments scan the atmosphere five times each second as the result of the satellite's spin stabilization.
Orbit: Sun synchronous at 536×540 km, 95.45 min, 97.47 degrees.

UOSAT 1981-100B, 12888

Launched: Piggy back with SME.
Spacecraft data: A cuboid shape with solar cells on the larger faces, it is about 1m long and 0.5m square. The mass is around 50 kg. It was built by the University of Surrey.
Mission: To stimulate practical interest in space science among students in schools, colleges and universities and to provide radio amateurs with a tool for studying the ionosophere. Onboard equipment includes a slow scan television camera with a 500 km square view of the Earth. Telemetry is transmitted in the 2m amateur radio band on 145.825 MHz either as coded data or using a voice synthesiser with a vocabulary of about 150 words.
Orbit: As for SME.

COSMOS 1314 1981-101A, 12895

Launched: 1039, 9 Oct 1981 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1307.
Mission: Possibly military photo-reconnaissance, part or all of the payload was an Earth resources survey package. Recovered after 13 days.
Orbit: 212×235 km, 89.02 min, 82.34 degrees with small manoeuvres to counteract decay.

RADUGA 10 1981-102A, 12897

Launched: 1658, 9 Oct 1981 from Tyuratam by D-1-E+apogee motor.
Spacecraft data: A cylinder with a pair of solar panels, and an aerial array at one end. Length about 5m, maximum diameter about 2m and mass (in geostationary orbit) around 2000 kg.
Mission: To provide round-the-clock radio and telegraphic communications in the UHF band and to relay Central television colour and monochrome programmes to stations of the 'Orbita' network.
Orbit: Initially a low, parking orbit at 51.6 degrees, then to an elliptical transfer orbit at 47 degrees prior to injection into geostationary drift orbit, before final stabilisation at 84 degrees east longitude (Statsionar 3).

COSMOS 1315 1981-103A, 12903

Launched: 2258, 13 Oct 1981 from Plesetsk by A-1.
Spacecraft data: Possibly based on the Meteor satellites with a cylindrical body and two, Sun-seeking solar panels. Length about 5m, diameter about 1.5m and mass around 2000 kg.
Mission: Electronic reconnaissance, replacement or backup for Cosmos 1154 (1980-8A).
Orbit: 625×665 km, 97.68 min, 81.19 degrees.

COSMOS 1316 1981-104A, 12905

Launched: 0914, 15 Oct 1981 from Tyuratam by A-2.
Spacecraft data: As Cosmos 1307.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 232×278 km, 89.65 min, 70.34 degrees with manoeuvres to counteract decay.

MOLNIYA-3 (17) 1981-105A, 12915

Launched: 0556, 17 Oct 1981 from Plesetsk by A-2-e.
Spacecraft data: Cylindrical body housing instrumentation and the payload is surmounted by a conical motor section. Power is provided by a windmill of six solar panels. Length is about 4m, diameter 1.6m and mass around 2000 kg.
Mission: Replacement or backup to Molniya-3 (12), 1979-48A. The previous attempt to fly this mission ended in failure, see Cosmos 1305 (1981-88A). The satellite provides long distance telephone and telegraphic communications and transmits Central television programmes to 'Orbita' ground stations, not only within the USSR but also to ground stations in other countries.
Orbit: Initially a low parking orbit and then injected into a highly elliptical orbit of 618×40646 km, 736.29 mins, 62.82 degrees. Later manoeuvred to 617×39771 km, 718.41 min, 62.81 degrees to ensure daily repetition of ground tracks.

VENERA 13 1981-106A, 12927

Launched: 0602, 30 Oct 1981 from Tyuratam by D-1-E.
Spacecraft data: Cylinder with two solar panels and an experiments package located at one end. Length (excluding experiments) about 2.7m, diameter about 2.3m maximum, mass around 5000 kg.
Mission: Continuation of the Soviet Union's Venus exploration programme, the craft is due to arrive near Venus in March 1982 and may carry a surface lander.
Orbit: Heliocentric, but initially a low parking orbit around the Earth at 51.6 degrees.

IMEWS 12 (OPS 4029) 1981-107A, 12930

Launched: 0922, 31 Oct 1981 from Eastern Space and Missile Centre by Titan 3C.
Spacecraft data: Not available.
Mission: US Air Force-launched Early Warning satellite for missile launches.
Orbit: Geostationary.

COSMOS 1317 1981-108A, 12933

Launched: 2252, 31 Oct 1981 from Plesetsk by A-2-e.
Spacecraft data: Possibly based on the Molniya design, see Molniya-3 (17) above.
Mission: Probably part of the USSR's system of missile early warning satellites.
Orbit: Initially a low parking orbit and then injected into a highly elliptical orbit of 584×40162 km, 725.75 min, 62.87 degrees. Later manoeuvred to 585×39788 km, 718.14 min, 62.89 degrees to ensure daily repetition of ground tracks.

UPDATES:

RADUGA 7 1980-81A was the first Statsionar 3 satellite, not Statsionar 1 as originally described.
COSMOS 1285 1981-71A may have been a failure, the usual manoeuvre to stabilise the ground track had not been forthcoming by mid-November 1981.

JBIS

The 12 monthly issues of JBIS for 1981 cover a wide range of technical space projects with issues of SPACE CHRONICLE; SPACE TECHNOLOGY; ASTRONAUTICS HISTORY; INTERSTELLAR STUDIES and IMAGE PROCESSING.

The contents of the issues which have been published up to the end of July 1981 since the last list (*Spaceflight*, January 1981) are given below.

Members can obtain the 12 copies of JBIS for 1982 for £16.00 ($39.00), postage inclusive. Single copies of the March-December 1981 issues may be purchased at £1.50 each ($4.00).

Orders can be included in the annual subscription renewal notice or sent separately to: The Executive Secretary, British Interplanetary Society, 27/29 South Lambeth Road, London, SW8 1SZ.

December 1980 SPACE TECHNOLOGY

W. Westphal, et al	Conditions and Requirements for a Potential Application of Solar Power Satellites (SPS) for Europe.
Johnson Space Center	Space Operations Center – a Concept Analysis.
A. Di Cecca and R. Gamberale	The Data Handling Subsystem On-board the Exosat Spacecraft.
H. M. Mooney	The Design of a Satellite-based System for Coastal Oceans Monitoring.

January 1981 SPACE CHRONICLE

D. M. Ashford and G. C. J. Larrouceau	Project Spacecab – a Minimum Cost Orbital Taxi.
A. Wilson	A History of Balloon Satellites.
F. H. Winter	Alfred Africano (1908–1980).
J. N. James	The Planetary Exploration Programme after Two Decades.
J. D. Burke	The Future of Lunar Exploration.

February 1981 SPACE TECHNOLOGY

P. D. Biggs and J. L. Blonstein	L-Sat – Europe's Satellite for the Eighties.
R. C. Parkinson	Earth-Moon Transport Options in the Shuttle and Advanced Shuttle Era.
D. P. Williams and S. R. Sadin	Technology – the Path to the Next 50 Years.
G. Peters and A. Lemarchand.	European Space Transportation Approaches.
A. Bourgine and J. Dordain	Review of Acoustic Studies Carried Out at ONERA in the Field of Space Vehicles.

March 1981 INTERSTELLAR STUDIES

R. W. Stimets and E. Sheldon	The Celestial View from a Relativistic Starship.
K. Bahadur and P. K. Varma	Histochemical Study of Lipid-Like Material.
U. R. Rao	Evolution of Life and Intelligence on Earth.
E. J. Coffey	Hominid Evolution and SETI.
C. E. Singer	Questions Concerning Pellet-Stream Propulsion.
P. M. Molton	Exobiological Notebook.

April 1981 IMAGE PROCESSING

J. Renes and D. Beintema	The Use of B-Spline Approximation and an Array Processor in the IRAS Ground Operations and Preliminary Analysis Facility.
N. J. Mulder	Three Elementary Tools in the Processing of Remote Sensing Data – A Unifying Approach.
M. Ranieri, et al	Coded Aperture Telescopes For Hard X-Ray Astronomy.
J. J. Lorre and R. B. Pomphrey	Multispectral Enhancements for Astronomical Images.
A. C. Davenhall, et al	An Astronomical Image Processing System Written in FORTH.
D. J. Telfer	Small Systems Processing of Planetary Imagery.
D. J. Stanley and P. S. Redstone	High Throughput Image Preprocessing Techniques for Earth Resources Imagery.
A. Buratti	Capabilities of IDR-Augmented Ariane.

May 1981 SPACE CHRONICLE

V. A. Galouri and D. R. Saxton	Orbital Transfer Vehicle – An Overview.
J. Powell	The Space Test Program.
E. I. Robson	The Primordial Fireball.
H. J. Driver and C. E. Perry	Further Salyut 6 Manoeuvres.
P. J. Boston	Low-Pressure Greenhouses and Plants for a Manned Research Station on Mars.
A. Wilson	The Scout Launcher – An Update.
N. L. Johnson	An Algorithm for Classifying Soviet Photographic Reconnaissance Satellites.
D. E. Koelle	The Next Generation of Launch Vehicles.
G. Vulpetti	On the Physical Meaning of Modern Propulsion.
P. S. Clark	Soviet Launch Vehicle Designations.

June 1981 INTERSTELLAR STUDIES

M. C. de San	The Ultimate Destiny of an Intelligent Species – Everlasting Nomadic Life in the Galaxy.
M. W. Saunders	Star Distance Diagrams.
W. Stuiver, et al	On the Composition and Deployment of a Space-Based Interstellar Search System.
S. Ranganayaki, et al	Photochemical Fixation of Carbon Dioxide By Jeewanu, the Protocel.
H. Lemke	Instantaneous Communication Over Cosmic Distances.

July 1981 SPACE CHRONICLE

W. I. McLaughlin	The Natural History of Halley's Comet.
N. L. Johnson	Estimated Operational Lifetimes of Several Soviet Satellite Classes.
T. R. Meyer	Extraction of Martian Resources for a Manned Research Station.
J. P. Bagby	Natural Earth Satellites.
D. Stott and M. Hempsell	The European Space Tug: A Reappraisal.
A. Wilson	Agena – 1959 to 1979.
C. Peebles	The Stratolab Programme: Manned Balloons to the Edge of Space.

SOCIETY MEETINGS

FLYING A CELESTIAL KITE


Guy Pignolet (left), a Documentation Engineer with CNES, described the managerial side of a solar sail race. Guy began as an oil-field engineer, moved onto teaching at Cornell University and now works with the French space agency. At right is Alain Perrett, also of CNES.

The concept of using sunlight to propel spacecraft sporting vast arrays of lightweight sails is certainly catching the imagination of people in the space world these days. All manner of exotic missions across the depths of the Solar System have been proposed—trips over the Sun's poles and multiple asteroid rendezvous, for example. It was this kind of imaginative thinking that attracted a capacity audience to the Society's "Solar Sail Race" meeting on the evening of 17 November last. Chaired by Peter Conchie, Member of the Council and Chairman of the BIS Space Technology Committee, no less than six main speakers were introduced, together with a half hour video presentation sent especially from California by Rob Staehle of the World Space Foundation.

The meeting came about after several CNES engineers — *albeit* on an unofficial basis — contacted the BIS with a fascinating proposal: to launch a number of solar sails into a geostationary transfer orbit by an advanced Ariane for a race to the Moon. An on-board motor would raise the perigee to several thousand kilometres (to circumvent the problems of atmospheric drag at low altitudes) and the sails would then be deployed. Correct orientation of the sails would gradually raise their apogee heights until the Moon was reached and the winner would be the first to reach occultation.

The whole project divides into two broad areas, both of which are vital for success. First, it has to be technically feasible — and that has not yet been demonstrated by any means. Second, the drumming up of support and general administration which will, perhaps, prove to be the most difficult aspect.

The World Space Foundation is currently leading the way forward in both areas — they deployed a test sail on the ground on 25 August last year and they seem confident of sending a sail into space by 1985-86.

Like so many ideas, the genesis of solar sails stretches back to the pioneering days of astronautics. The theoretical groundwork was laid by James Clerk Maxwell in 1873 when he predicted that electromagnetic radiation exerts a small, but nonetheless finite, pressure. This is demonstrated by the fact that the tails of comets stream away from the Sun, but it was not until the turn of this century that Lebedev in Russia and Nichols & Hull in the US actually came up with experimental proof.

It appears that the first mention of solar sails themselves was in 1924 by F. A. Tsander, who said "For flights into planetary Space, I am working on the idea of flying using tremendous mirrors of very thin sheets. . . . The low pressure of light over the tremendous distances of travel will result in tremendous flight speeds. . . . The greatest time . . . to . . . Mars . . . will be about 256 days." (Taken from NASA report TTF-541, p.29.) At the same time, Tsiolkovsky had an interest in the subject.

Apart from a number of publications, such as Arthur C. Clarke's "Sunjammer" story of 1965 (concerning a manned race to the Moon), and work by Garwin in 1958, (who coined the term "solar sail") there the matter stood until it was resurrected by NASA and ESA studies of the 1970's.

Since the above report was written we have discovered that Krafft Ehricke, a BIS Fellow, looked at solar sailing in the early 1960's. A brief description of this work will be carried in next month's Society News.

NASA's interest stemmed from the approach of a major celestial visitor - Halley's Comet - in 1985/86. Halley is scientifically important because it appears to be still "fresh" and its relatively well-known orbit provides us with an opportunity to send instruments to probe its secrets from close up. Unfortunately, it is in a retrograde path around the Sun and any probe designed for a long-look mission needs large velocity and orbit-inclination changes.

To send a large experiments package (the Japanese ballistic probe carries a mere 10 kg of instruments) requires performances better than today's chemical rockets can provide. Solar sailing and electric propulsion were studied as propulsion candidates and would, no doubt, have been taken further had the money been forthcoming.

The NASA/JPL Halley rendezvous study considered a sail area of 624,000 m^2, and a total spacecraft mass of 4900 kg, resulting in an acceleration of about 1 mm/s^2. Not very high, but over a long period the speed would build up.

ESA, on the other hand, was interested in a study for a demonstration flight using an Ariane-launched sail. A surface made of 2 micron thick Kapton with an area of 60,000 m^2 would accelerate at about 0.74 mm/s^2 if the total mass were 650 kg.

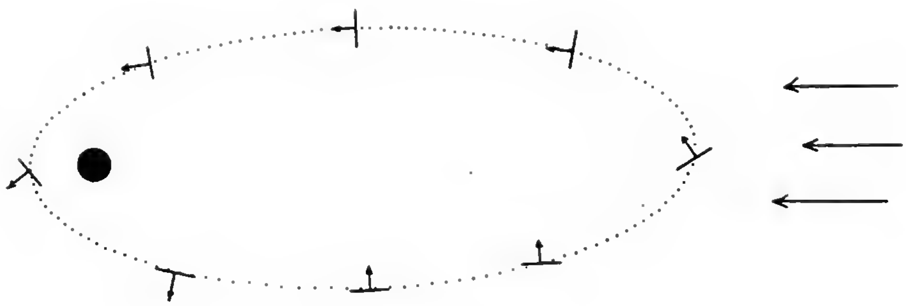
During 1979, Eric Drexler of MIT pointed out that manufacturing the sails in space instead of assembling them on the ground and then taking them through the rigours of a launch could result in much larger areas. Freeman Dyson also pointed out that a sail illuminated by a large ground-based laser would be a good candidate for an interstellar journey.

The World Space Foundation - President Robert Staehle is a BIS Member, - began in 1979/80 to seriously consider building a small sail for testing in Earth orbit. Under sponsorship from such organisations as the Charles A. Lindbergh Fund, together with the support of JPL and other bodies, they came up with the EDM concept. This is the Engineering Development Mission, currently aiming for a 1985 launch, which will take a test sail into a highly elliptical orbit for deployment. Engineers can then see how the sail behaves and learn to control its attitude - crucial for determining the orbit - and possibly see it travel beyond the Moon some two to three years later. A sail area of only 880 m^2 would yield a solar force of 0.007 N, sufficient to perform test manoeuvres.

At launch, the square sail and its four diagonal supports are designed to be folded on reels on the main spacecraft, waiting for deployment once the denser regions of the atmosphere have been cleared. Attitude control comes from vanes on two opposing corners, built-in dihedral of the supports and the movement of a TV camera (to shift the centre of mass).

A prototype, 15 m square and made of 38 cm-wide Mylar strips (Kapton is too expensive for these early models!), was deployed last August and WSF hope to have a full size prototype ready by the summer.

The orbital manoeuvres of a Moon racer (not to scale). Arrows coming in from the right represent Sunlight, small arrows on the sails show the thrust direction. The energy is picked up on the inward leg of the orbit, while on the outward section the sail lies parallel to the Sun's rays to prevent deceleration. Note the 180 degree phase change on the outward leg – if the sail is reflective on both sides this manoeuvre is not necessary.



The WSF proposals excited the interest of some CNES engineers who, working in an unofficial capacity, considered an Ariane launch which would take several sails into space for a race to the Moon. Guy Pignolet and Alain Perret travelled from France for the meeting to describe the project as they see it now, still in its very early stages.

The sail concept shown by M. Perret pictured an octagonal form with eight polyurethane supporting spars, carrying a central package for electronics, telemetry, etc. Attitude control would be achieved by shifting this package – a movement of less than a metre would be sufficient – and by distorting the spars. Ariane would leave, say, three sails in a 36,000 × 3,000 km orbit to begin deployment and, by appropriate orientation, to extend that 36,000 km apogee to lunar distances. A sail with an area-to-mass ratio of 14 would take over two years to reach its target, but by increasing the reflecting surface so that ratio is 25 would reduce the travel time to around a year.

The designing, of course, would have to be done with the Ariane launch environment very much in mind – it would be no good starting a race with one of the sails torn because of launch vibration. Another problem is that, as presently envisaged, three sails would be packaged inside cans for installation in the lower payload compartment of a dual Ariane launch, and their positions may affect their performances. A case for a handicapping committee, maybe?

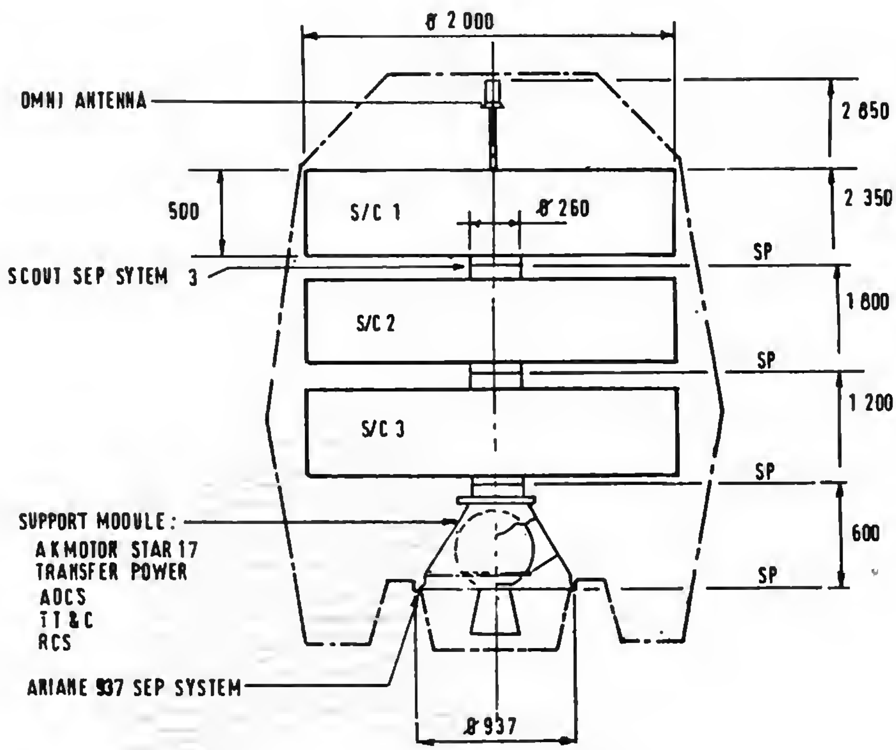
Since it is a race, there would have to be a body to set the rules (one speaker pointed out that it should be made illegal to gain speed by irradiating a sail with a laser beam!) and judge the race while it is actually underway.

The idea of holding such a race was formulated to catch the attention of sponsors. How should the sponsorship be organised? Should there be an overall sponsor (someone has to pay for the launch) and then individual sponsors for each sail which may be built by different teams? Who would decide which entries would be selected? A committee may have to monitor the designs to make sure that a particular sail is up to the job – there's no race if only one makes it to the Moon!

This area is vital if the project is to get off the ground at all and much of the energy expended will go into establishing the management structure. It was pointed out that the educational UOSAT satellite launched last year took much less time to actually build than did the organising of the project.

But if all goes well, and enough support can be found, we may well see a number of celestial kites drifting towards the Moon in the later years of this decade.

The views expressed in this report are not necessarily those of the speakers. The WSF kindly provided much of the background material.



A possible configuration for a triple Solar Sail launch by Ariane using the Sylda system (see text above).

BOOK REVIEWS

The R.A.E. Table of Earth Satellites 1957–1980
Compiled by D. G. King-Hele, J. A. Pilkington, H. Hiller & D. M. G. Walker, Macmillan Reference Books, 656 pp, 1982, £30.

Judging from correspondence received over the years, this is a volume which has long been awaited.

It is, basically, a reproduction of the tables produced by the Royal Aircraft Establishment in the form of a chronological list of the 2145 launchings of satellites and spacecraft between 1957 and the end of 1980, giving the name and international designation of each satellite, its associated rocket(s), together with details of launch, lifetime and other satellite dimensions. Fragments associated with launch and space vehicles which also entered orbit are given, though without details.

If one includes these fragments, then more than 12,000 satellites appear in the tabulated text which is, incidentally, fully indexed!

By the time Sputnik 1 was launched on 4th October 1957, RAE scientists had already made several studies of Earth satellites and orbits, stemming from earlier work in the 1950's from Blue Streak and Skylark. Within a few days of launch, Sputnik 1 was being regularly tracked by a radio interferometer at the RAE's outstation at Lasham. The satellite's orbit was determined from these observations and the decay rate used to evaluate upper-atmosphere density.

By the time Sputnik 2 was launched, the need for a regular prediction service was recognized. First, this was provided by the Royal Greenwich Observatory but was taken over by the RAE in January 1958.

From these small beginnings, the Table, regularly issued to observers, has, like Topsy, "simply growed" – though the original format has been retained almost unchanged, apart from conversion into metric units.

Readers acquiring this volume will find much of interest. The short introduction not only explains the interest of RAE in satellite observations but also includes a description of orbital characteristics and some of the bases used.

One then proceeds to the tables proper, reproduced from original masters, and which form the great mass of content of the book.

The work in preparing such tabulated data in a form suitable for permanent reference is much to be admired. One can only marvel at the enormous amount of effort which must have gone into the eventual production of this volume.

Cosmology
E. R. Harrison, Cambridge University Press, 430pp, 1981, £15.00.

Man has made countless attempts to find order for the cosmos and provide an explanation of its nature and meaning.

For much of Man's history, cosmological thought was formulated in religious or philosophical language and was thus either theological or metaphysical in nature. Nowadays, however, cosmological speculation and theory has become a science in which the empirical discoveries of the astronomer, theoretical physicist and biologist are woven into intricate models that attempt to explain the Universe as a whole.

This book provides an introduction to past and present theory. The author draws on the discoveries and speculations of scientists from every age to provide a comprehensive survey of Man's understanding both of the current nature and the history of the Universe. It introduces the reader not only to familiar objects such as stars and galaxies, but to the more esoteric elements, such as curved space, black holes and cosmic horizons.

Here you will find the principles of General Relativity discussed in easy form, the problems of expansion of the Universe (redshifts) – perhaps even the "many universes", with extensive bibliographical references.

The Traveller's Guide to the Solar System
R. Miller & W. K. Hartmann, MacMillan, 192 pp., 1981, £8.95.

Nearly everyone will be pleased to possess a book of artistic impressions like this. The opening picture, *Saturn from Tethys*, is both beautiful and arresting, though it must not be supposed that only the planets are dealt with – many of the minor worlds which make up the Solar System e.g. satellites and asteroids find their place, including even the ring surrounding Jupiter. As with all artistic impressions, much depends upon the eye of the beholder. Some pictures will undoubtedly prove to be favourites, while others may only excite ribald comment.

With so much to be encompassed in so few pages, it follows that the number of pictures per planet is necessarily small but, nonetheless, the treatment is fairly extensive, and with a few actual photographs inserted to compare imagination with reality.

Although the general impression is entrancing, your reviewer must confess to some disappointment on the small section devoted to Comets. This tended to fall short, particularly when one bears in mind the beautiful drawings of such objects which have appeared in the past.

Giant Molecular Clouds in the Galaxy
Eds. P. M. Solomon and M. G. Edmunds, Pergamon Press, 344pp, 1980, £21.

The mapping at mm wavelengths of spectral line emission from molecules in the Galactic disc has led to the discovery of a new and very important feature of the interstellar medium – the Giant Molecular Clouds. Such clouds are a major Galactic component in terms of mass and must have had a fundamental influence on Galactic evolution, since it appears that they are associated with most (if not all) of the formation of massive stars taking place at the present time.

During the past three years there has been a tremendous expansion of observational studies of molecular clouds of all types and the beginning of interesting theoretical work on the relationship of such clouds to star formation. The discovery of a galactic ring of molecular clouds between 4 and 8 k.p.c. from the Galactic centre demonstrates the widespread occurrence of these in the Galactic disc.

This book brings together the papers presented at a discussion on the subject held at the University of Wales in 1977. It describes both the mapping of nearby complexes of clouds as well as the large-scale galactic survey which it required. Infra-red properties, showing the structure, are reviewed by Dr. Rowan-Robinson, with two further papers discussing the galactic centre itself, certainly the most massive complex. One of the best known clouds, containing about 1/10 of the mass, is that associated with the compact HII region Sagittarius B2.

Star formation receives no less than 10 papers, including one on supernova-induced star formation and another on NGC 7023, as an example of low-mass star formation.

For good measure, the short paper which ends the volume has the title of "The Search for other Planetary Systems": it concludes that there is still a state of uncertainty as to whether other planetary systems exist or not.

A Revised Shapley-Ames Catalog of Bright Galaxies
A Sandage & G. A. Tammann, Carnegie Institution of Washington, 157pp. 1981, $29.

In 1932, Shapley and Ames published their Harvard Survey of 1246 bright galaxies. Their work became the basic listing of bright galaxies and, although supplemented by later reference catalogues, still plays a major role in studies of galaxies in the local region.

In the early 1950s, Sandage set out a plan to compile the type, magnitude, and red-shift data for all galaxies in the original Shapley-Ames catalogue. The project, later joined by Tammann, was an outgrowth of the photographic survey of bright galaxies begun at Mount Wilson in 1909 and continued at Palomar after completion of the 200-inch Hale Telescope in 1949. Where necessary, new plates were obtained for the classification and many new red-shifts were determined. Much of the effort was in the Southern Hemisphere, initially in Australia and later at the Las Campanas Observatory, Chile, where the 100-inch du Pont telescope came into operation in 1977.

The result of that long-range programme is the present catalogue, containing data on types, magnitudes, and red-shifts for the Shapley-Ames galaxies. The types are based on the modified Hubble system. Luminosity classes are on a consistent system, defined in the catalogue and illustrated with type examples. Red-shifts are from literature sources up to the summer of 1980, combined and weighted as discussed by the authors.

The main catalogue consists of 58 pages, together with 90 illustrations of galaxies to exemplify luminosity classes.

The above notes are not Reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

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APRIL 1982
VOLUME 24 No. 4

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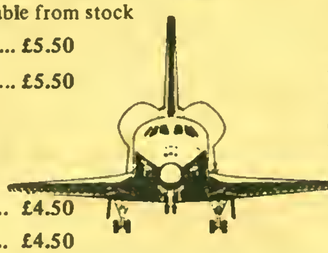

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POSTER: THE UK FROM SPACE

The National Remote Sensing Centre at RAE Farnborough recently produced direct from its digital computer tapes a poster of the UK in false colour based on a mosaic of 43 images from Landsat satellites. In such false colour, different features on the surface – for example vegetation, urban areas and water – are reproduced in totally arbitrary colours and in this almost totally cloud-free image such features can be seen in considerable detail. Besides England, Wales, Scotland and Northern Ireland, the eastern part of the Irish Republic is reproduced. The poster measures 28″ x 19″ and is posted rolled in a tube. A natural for schools and colleges as well as individual enthusiasts. Price includes separate detailed description.

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CONTENTS

147 **Manufacturing on the Moon?** *H. H. Koelle*

151 **Exploring Mars with Kepler** *Andrew Thomson*

154 **Soace Reoort**

165 **Hipparcos: Europe's Astrometric Satellite** *Neville Kidger*

167 **The U.S. Air Force Test Pilot School** *Curtis Peebles*

171 **Space Communications**

179 **The Recovery of American Manned Spacecraft 1961-1975** *Keith T. Wilson*

185 **Satellite Digest – 153** *Robert D. Christy*

187 **Society Meetings**

188 **The 36th Annual General Meeting**

190 **Society News**

191 **Correspondence**

COVER

Technicians wearing protective suits make their way to the Shuttle Orbiter *Columbia* in its Mate/Demate Device after the second flight last November. The hazardous task of removing the hypergolic fuel from the propellant tanks had to be completed before *Columbia* could be mounted on its transporter aircraft for the trip back to the Kennedy Space Center.

NASA

MILESTONES

January 1981

2 The Marecs 1 maritime communications satellite arrives at its geostationary position of 26 degrees west longitude. The European Space Operations Centre immediately begin testing to verify that the satellite is functioning according to specifications. Formal acceptance testing will be carried out in February by INMARSAT (International Maritime Satellite Organisation) which will lease the communications capacity over the Atlantic Ocean area. Marecs B is due for launch by Ariane L5 in April and will be stationed over the Pacific Ocean area.

4 A subsidiary of the US investment banking firm William Sword Co., Space Transportation Co., is considering the private procurement of a Shuttle Orbiter, reports Aviation Week. NASA are still unsure whether their own funds will cover the cost of a fifth Orbiter. The company says that "Our concept is to supply the fifth Orbiter and contribute it to the fleet, and then in effect become the ticket agent for the entire fleet".

5 British Aerospace announce that they have received the go-ahead to begin the construction of L-Sat 1, the first of the most powerful communications satellites in the world. L-Sat 1, weighing about 2300 kg and launched by Ariane in 1986, will demonstrate direct broadcasting to homes, business communications and new high frequency usage. BAe expect that more than 150 satellites of the L-Sat class will be required by the end of this century, worth about £5,000 million at today's prices. BAe have also received an £80 million contract for the Skynet 4A and 4B military communications satellites, due for launch in 1985.

11 Launch of Exosat, Europe's X-ray astronomy satellite, is delayed until October because of problems with one of the experiments. The original August launch date could have been met but an ESA meeting last month decided that the schedule would have been too tight.

12 75th anniversary of the birth of Sergei Korolyov, creator of the Societ space programme.

12 The Soviet Cosmos 1332 satellite is launched into a 224 × 205 km orbit inclined at 82.3 degrees. The parameters are consistent with the craft being an imaging reconnaissance satellite.

17 The External Tank for the fourth Shuttle flight begins its five day journey from the Michond Assembly Facility in New Orleans to the Kennedy Space Center.

18 It is reported that Swedish students at a practical astronomy class at the University of Umea photographed the launch of the Meteor 2 satellite from Plesetsk last May.

21 A US high resolution reconnaissance satellite is launched into polar orbit from Vandenberg AFB by a Titan IIIB.

25 A meeting of representatives from ESA's Member States participating in the Ariane programme declares the launcher to be operational. Ariane L5, due for launch at the end of April, will be the first of the seven-vehicle "promotion series." Thereafter, the private Arianespace company will handle the launcher.

27 Fifteenth anniversary of the Apollo 1 fire in which astronauts Crissom, White and Chaffee lost their lives.

В журнале не печатается ряд страниц.

12-14 NOVEMBER 1982 AT THE BRIGHTON CONFERENCE CENTRE

SPACE '82 A VISION OF THE FUTURE

Our Space '82 "weekend" is now at the new Brighton Conference Centre, purpose-built to meet the needs of conferences. It is equipped with every modern facility and is also close to the famous Regency Pavilion, which we now intend to include in some of our functions.

Brighton Corporation have agreed to provide a wide range of hotel accommodation on our behalf and to deal with all the formalities. All that members will need to do is to complete a simple form indicating their requirements and the price range they have in mind - the scope of facilities at Brighton is so great that almost everyone should find something to their satisfaction.

An added attraction is that all participants will be invited to an opening Reception in the Regency Pavilion as guests of Brighton Corporation and the Society.

We now have access to excellent display facilities to produce an even more exciting programme - one that members simply will not wish to miss. Make a note and join us in Brighton on **12–14 November 1982**.

Our programme is developing all the time but here is a basic description of how things stand at present:

12 November (Friday)

Registration in the early evening is followed by an informal buffet supper with our President and Martin Fry, Space '82 organiser, who will welcome visitors and introduce some of our special guests.

13 November (Saturday)

This will be a very full day indeed.

Part of our programme includes: Dr. T. O. Paine (ex-NASA Administrator) and Raefe Shelton of British Aerospace posing the question: *The Energy Problem - Can Solar Power Satellites provide the Answer?* Gene Roddenberry of "Star Trek" fame will speak on *Space: A Vision of the Future*, and Burt Edelson (COMSAT Vice-President) will consider *Space Communications - The Universe at Our Fingertips*. A session on *Into Deep Space* will discuss exploration of the deeper recesses of Space.

Burt Edelson of COMSAT will talk about the exciting potential of communications using space technology.

Breaks for coffee and lunch will give visitors the chance to mingle with our distinguished guests and see some of the displays (ESA have agreed to provide a collection of models).

A particularly interesting session will be held on the 1985/86 return of Halley's comet. Probes to Halley will be launched by Europe, the USSR and Japan in an effort to answer fundamental questions about the early history of the Solar System. Our chairman will be Dr. D. W. Hughes who can be said to have originated the European *Giotto* probe scheme with his paper "The Direct Investigation of Comets by Space Probes" in the Society's *Journal* in 1977. Dr. R. Reinhard and R. M. Jenkins, responsible for the scientific and engineering aspects of Giotto, will add to our coverage of this major event with overviews of how the spacecraft will work and what it will do.

An informal evening banquet will conclude the day.

14 November (Sunday)

Sessions will include speakers such as Dr. Gary Hunt (*Exploration of the Solar System*), Dr. Bill McLaughlin of JPL. (*Evolution of Man and Machine*), and Capt. R. F. Freitag of NASA (*Space Industrialisation*).

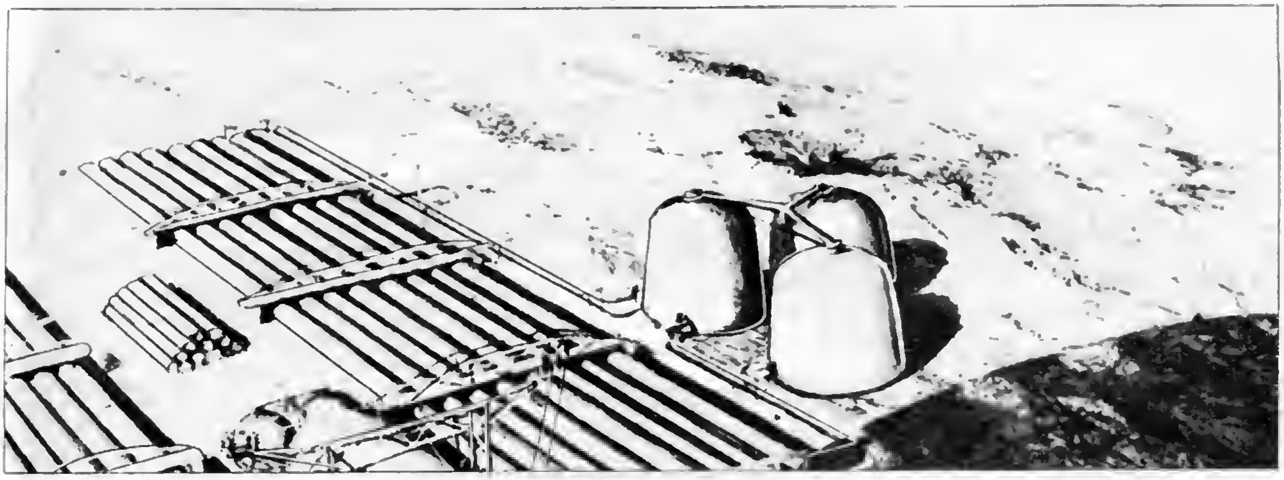
This is only part of our basic programme. There will be many additions in the coming months to make this a not-to-be-missed event.

Registration forms are available on request. A fully detailed brochure will be available and will be sent automatically, to those who have expressed interest in it. Applicants from now on should enclose a 20p stamp.

Alan Bean, Apollo and Skylab astronaut, will be one of our guests at Space '82.

MANUFACTURING ON THE MOON?

H. H. Koelle*



When we begin to build large space structures, such as the huge Solar Power Satellites, should we use the Moon as a construction base? This was the question posed in a student study project at the Technical University Berlin, and the summary below describes the work carried out up to last autumn.

Introduction

In recent years it has become evident that the Earth's resources are limited. The shortage of energy during the seventies produced a major effort to look for other sources. One of the alternatives studied was the Space Solar Power System, proposed by P. E. Glaser more than 20 years ago. At that time, the first detailed analysis of a lunar base was performed by the US Army Ordnance Corps (Project Horizon), which was one of the inputs leading to the Apollo programme. During these renewed studies of space solar power stations the question of using lunar raw materials for construction was studied by General Dynamics with rather encouraging results. This information supported Krafft Ehricke's notion of developing a Lunar Industry.

The emphasis of our analysis was to lay the ground work for a detailed mathematical model which could be used for detailed analysis and tradeoff studies of a lunar base producing raw materials and stock of about 100,000 tonnes per year. First, a frame of reference was defined which included 20 elements of the presently envisaged lunar complex. These elements were defined with respect to mass, energy and personnel requirements. On this basis, a first estimate of systems performance could be accomplished, the results of which are given here.

At present, only conventional propulsion systems (liquid oxygen/hydrogen) are used within the system. LOX is produced on the lunar surface, while the hydrogen is imported by a heavy lift launch vehicle using the same propellants. Refuelling in lunar orbit is employed. This system model will be further developed into an operational computer model consisting of at least three modules which can be used independently.

Other candidate propulsion systems will probably do the same job cheaper, but these will develop later. We should study the question: which advanced propulsion systems should be introduced (and when) during a 50 year operational period? It is unclear at the present which of the possible technologies will make space solar power systems commercially competitive. It will take several years to come up with an answer that satisfies the relevant decision makers. If and when the industrialisation of the Moon becomes a reality, it will probably be an international project.

*Professor of Space Technology, Technical University Berlin.

Systems Definition

As illustrated in Fig. 1, we consider the Earth and Moon to be one system. We also need two Space Operation Centers (SOC), currently under study by Boeing Aerospace, stationed in low lunar and geostationary orbit to serve the space trans-

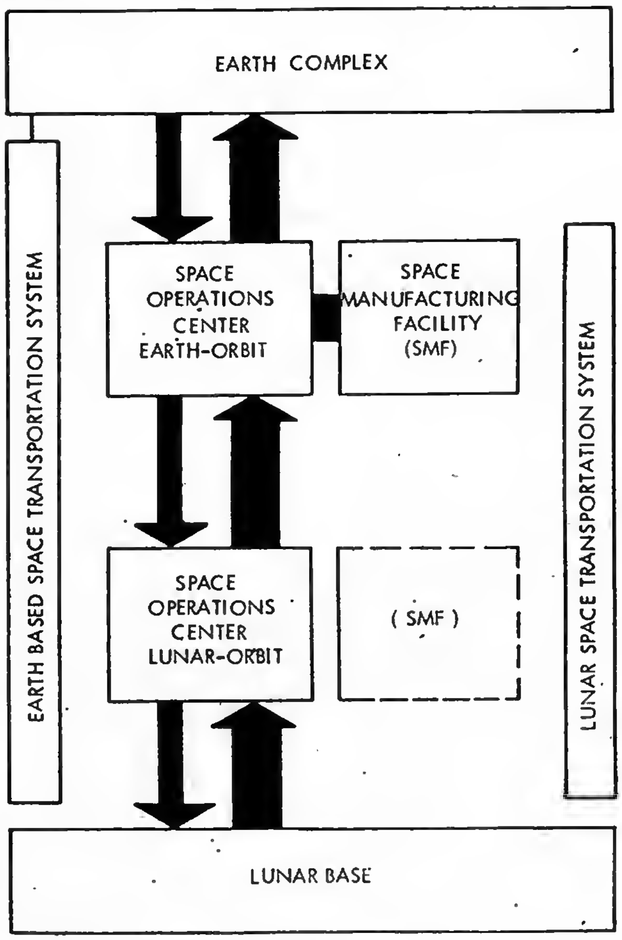


Fig. 1. System definition.

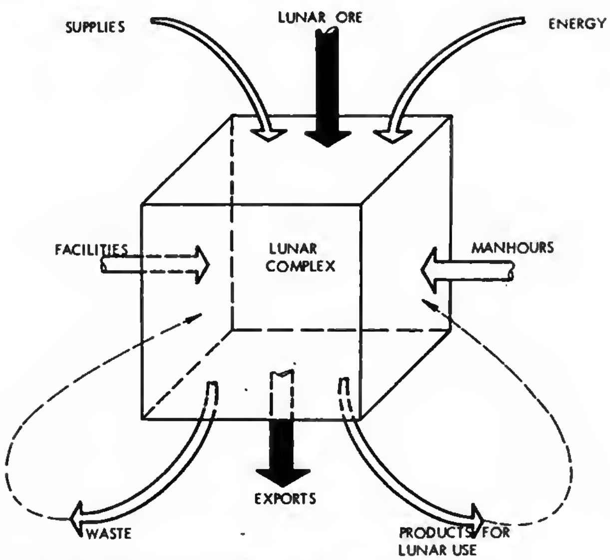


Fig.2. Basic structure of lunar base model.

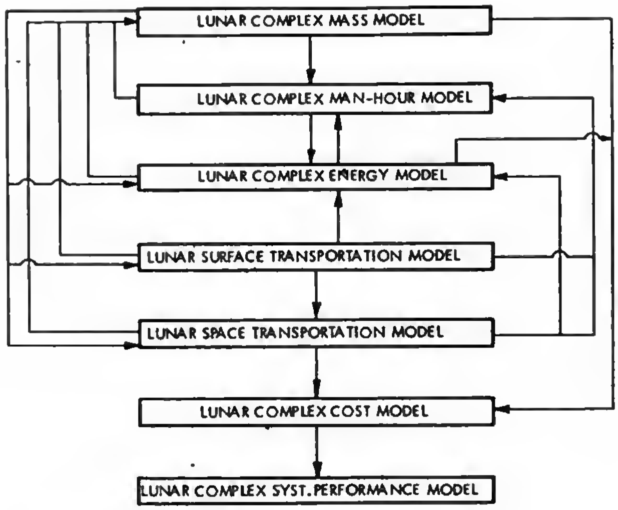


Fig. 3. Model structure selected for systems analysis.

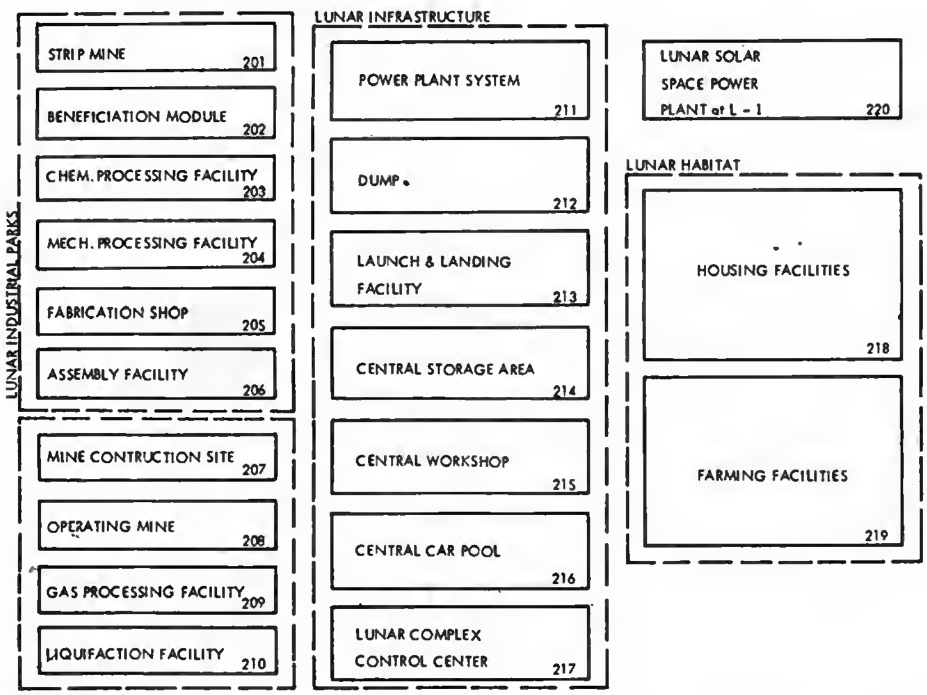


Fig. 4. Elements of the subsystem "lunar base".

portation system. The launch vehicles, space ferries and lunar buses will use these stations for maintenance, repair and refuelling. The manufacture of GEO-space power plants or space cities takes place at Space Manufacturing Facilities which can be located in GEO or in a low lunar orbit. The raw materials and components come from the Moon or Earth on a competitive basis.

An input-output model of the lunar base is shown in Fig. 2. We need facilities (initially brought up from Earth), energy, manpower, lunar ore and supplies. Taking all this, the lunar crew will produce a number of products, primarily (but not only) for export.

It takes some detailed modelling to analyse this rather complex process, which can be described with fair accuracy by some 200 variables. These are structured in several models, as shown in Fig. 3. These models interact with each other and, if the analysis is performed properly, produce some interesting results. We start out by describing our 20 elements of the system (shown in Fig. 4) in mathematical terms connecting them by their input-output relationships. Thus we can determine the mass flows, energy and manpower requirements. This, then, is the basis for estimating the cost of the system in annual increments. The industrial portion of the lunar base with the primary mass flows is shown in a schematic diagram in Fig. 5.

The space transportation system is part of a separate model, consisting of:

- Lunar bus
- Lunar interorbital ferry
- Earth-based heavy lift launch vehicle
- Space Operations Center in lunar orbit
- Space Operations Center in Earth orbit
- Earth space port
- Lunar space port

These elements will have to be taken into consideration when

Manufacturing on the Moon?/contd.

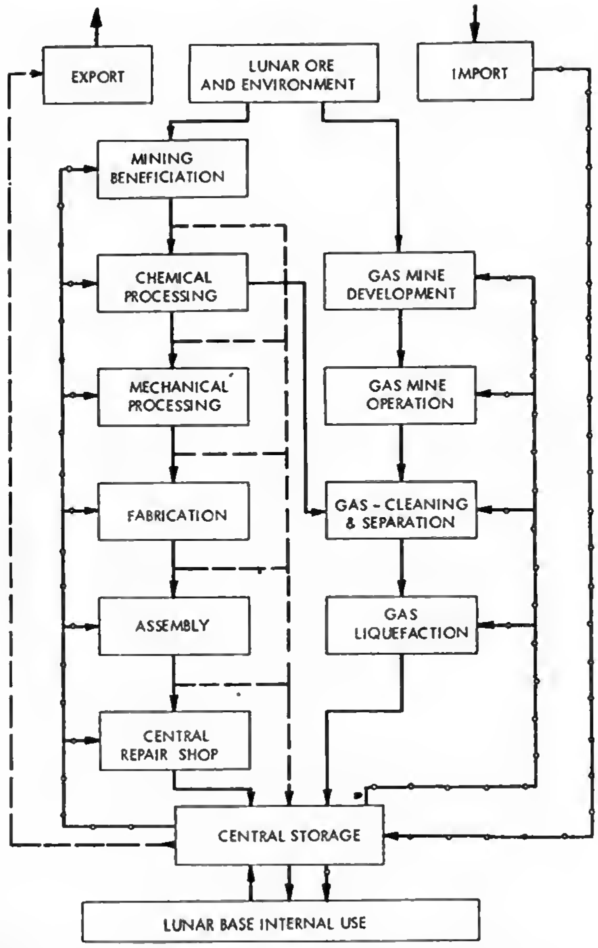


Fig. 5. Primary mass-flows within the lunar industrial complex.

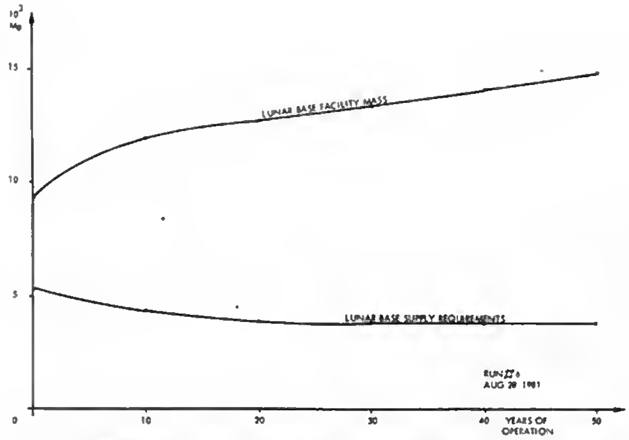


Fig. 6. Cumulative mass of lunar base facilities and annual supply requirements.

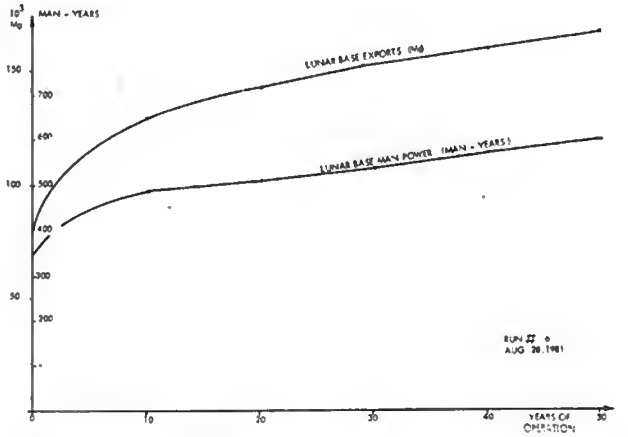


Fig. 7. Annual mass exported from the lunar base and crew size of the lunar base over life cycle.

estimating transportation cost. We use in our first generation model only state-of-the-art vehicles with Shuttle-type propulsion systems and thermal protection systems now under development and testing. This enables us to make calculations with a relatively high degree of confidence for the largest expenditure share of the whole system. At a later stage, we intend to investigate other modes of operation, including nuclear propulsion systems, to reduce transportation cost if and when this appears possible within our 50 years operation life cycle.

Preliminary Results

The first results of computer runs done in August 1981 show modest growth trends of the lunar base during its 50 year life cycle. Fig. 6 is a plot of the lunar base facilities mass and supply requirements against time. The lunar base starts out with a mass of about 9,000 tonnes and increases to about 15,000 tonnes. The supplies are reduced from about 6,000 to about 3,000 tonnes per annum during these 50 years. Fig. 7 shows the manpower requirements increasing from about 350 to about 600 people. The export products amount to about 80,000 tonnes p.a. in the first year and are doubled within the 50 year period. The facilities on the Moon with respect to total mass moved are less than 1%, a quarter of which comes from lunar resources. The oxidizer share of the propellants required is manufactured on the Moon, almost 86% of the mass required. The hydrogen comes from Earth and amounts to 13% of the total mass required.

If we sum the total system cost for a 50 year period with a total production of 5 million tonnes total we obtain the following estimates in terms of 1980 dollars $\times 10^9$:

1. Research and Development up to initial operational capability (ca.11 yrs.)	6.0
2. Sustained engineering and administrative support on Earth during operations	7.0
3. Manufacturing cost of initial equipment	3.5
4. Equipment replacement and spare parts through operational period	9.5
5. Cost of consumables during operation	12.0
6. Personnel training, salaries and transportation ES-GEO-ES	9.8
7. Transportation cost of personnel within the Lunar Complex (LS-GEO-LS) - propellants only! -	3.5
8. Transportation cost of initial equipment from Earth to the Lunar surface (150 flights at $22 M each)	3.3
9. Transportation cost for logistics supplies during operational period (500 flights at $12 M each)	6.0
10. Transportation cost for liquid hydrogen from Earth to Lunar orbit (12,700 flights at $12 M each)	155.8
Total	216.4

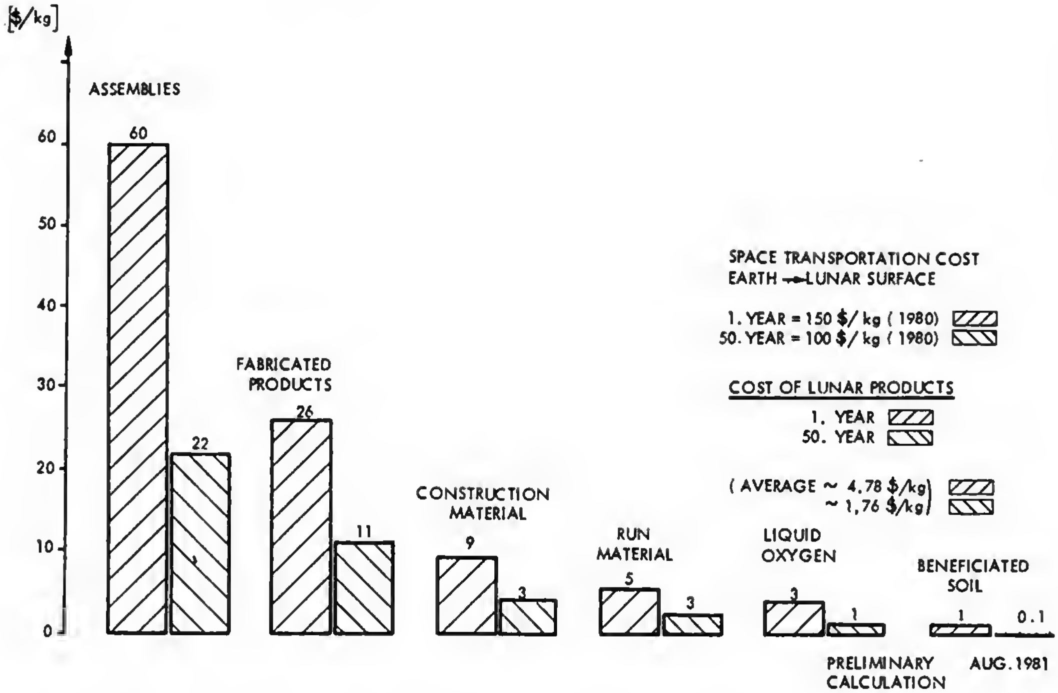


Fig. 8. Unit cost ($/kg)-1980 value of lunar products in the first and 50th year of operation.

In round figures, we have to pay $220,000 M dollars for 5,000 million kg, which is about $44/kg. Eighty per cent of these costs are related to space transportation, most resulting from the ferrying of hydrogen from Earth to lunar orbit.

We can also break the total cost down into acquisition cost and operating cost, 6 and 94 per cent, respectively. To transport the construction material to GEO from Earth's surface, the price would be about $130/kg!

From this we can see that manufacturing on the Moon would reduce the transportation portion of SPS to about one-third – the smaller gravity field of the Moon makes the difference. We need more than 10 times the energy to transport one unit of mass from the Earth's surface to GEO than doing the same job from the lunar surface. In terms of launch vehicle take-off mass, we would need to move more than 30 times as much mass from Earth. On the other hand, we have to take into consideration the mass of the lunar facilities and their logistic supply. This will make the ratios less favourable, but the case for lunar manufacturing is still impressive.

If we neglect the transportation cost of lifting the construction material from the lunar surface to GEO, we can calculate the cost of lunar products. This has been done in a preliminary fashion and the results are shown in Fig. 8. The average cost in the first year is approximately $5 (1980)/kg and in the 50th year less than $2 (1980)/kg. However, the cost for individual product groups differ, as indicated in Fig. 8. It ranges from less than $1 to more than $60/kg and it is easy to see that it is approaching the cost of transportation to the Moon (about $100 to $150/kg) in case of complex assemblies. Thus it can be concluded that products requiring many man-hours, such as electronics, will probably be imported from Earth.

Conclusions

The study is not yet completed but it appears that

1. lunar manufacturing leads to a significant improvement of systems effectiveness;
2. if space power systems in GEO are ever built, most of the construction material should come from the Moon;
3. using advanced propulsion systems, sometime during the 50 year life cycle, should further improve the system (we do not know at the present when and how);
4. it will be worthwhile to continue these studies during the next few years, so that the relevant information becomes available for a decision later this decade.

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EXPLORING MARS WITH "KEPLER"

By Andrew A. Thomson

Kepler is a European proposal, recommended for Phase A studies, which would put a satellite into orbit about Mars to bring the geophysical studies of that planet to the same level as Venus and Earth. If flown, it will be Europe's first planetary mission. We plan to publish further articles on European proposals in future issues.

Introduction

Kepler, named after the 17th Century astronomer Johannes Kepler, is an ESA proposal to place an unmanned geophysical research satellite in orbit around Mars, with launch opportunities in 1988 and 1990. Kepler will be a logical step in the first stage of unmanned Martian exploration, filling the gap left by the American Mariner and Viking and the Soviet "Mars" probes. Photographic reconnaissance and a search for evidence of life were the main scientific objectives of the NASA probes, but they gathered relatively little geophysical data. This is Kepler's role. (The Soviet probes did return some geophysical data but it was patchy and inconclusive - much like the "Mars" series of probes overall).

The limitations of Mariner and Viking in this respect were recognised by the Mars Science Working Group charged by NASA to study post-Viking missions. This Group suggested the inclusion in a very large "Mars 1984" mission (not approved) of a "Mars polar orbiter that would conduct a comprehensive global mapping of the geochemical provinces of the planet, its atmosphere, its gravity field, its magnetic field and the charged particles in its vicinity." Today we know that, after the NASA Pioneer Venus Orbiter mission (a mission comparable to Kepler, but around Venus) a similar geophysical orbiter of Mars could cover most of the areas of interest not studied by Mariner 9 and Vikings 1 and 2.

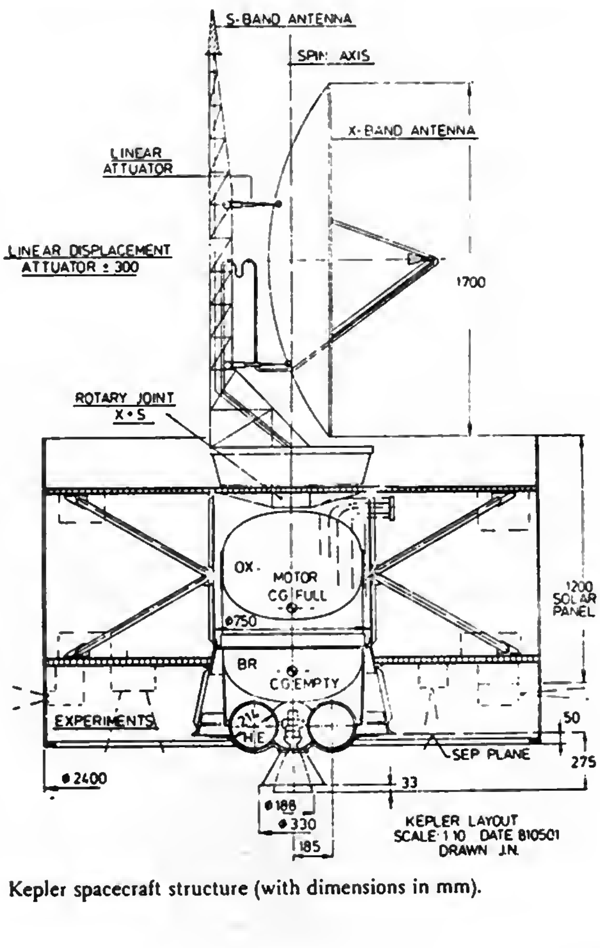
Kepler's scientific objectives are distributed over three broad areas: atmospheric science, interaction with the solar wind, and planetary surface and interior science.

Atmospheric Science

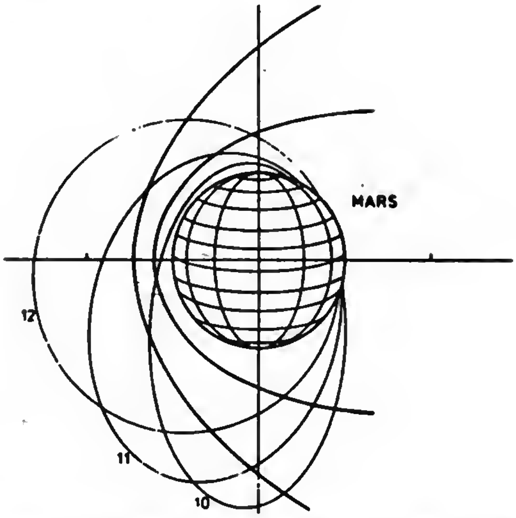
Fascinating glimpses of the climatology and meteorology of Mars have been obtained by previous space missions, but the subjects have never been systematically studied. To do that requires dedicated remote sounding instrumentation on a probe in an orbit inclined enough to the Martian equator to eventually cover all of the surface. Surveys by earlier craft have revealed the basic properties of the atmosphere: composition mainly carbon dioxide, surface pressure less than 1% of Earth's, varying strongly with season; vigorous circulation, strongly modified by surface topography. The latter, in turn, evolves under the influence of wind erosion and large-scale transport of dust; wind-blown dust is an important mechanism on mars for heating and cooling the atmosphere.

Kepler's objections are: (1) to determine the structure, composition and dynamics of the upper atmosphere, and how all of these vary with time, location and solar activity; (2) to monitor the global temperature pattern to permit an understanding of atmospheric circulation and its driving forces (measurements of the vertical temperature profile by the descending Viking landers were naturally very limited in coverage, in both time and area); (3) to study the distribution of airborne dust and the onset and evolution of major dust storms; (4) to study seasonal pressure variations (discovered by Viking); (5) to investigate ozone amounts (found by Mariner 9 to vary by a factor of 100 between the winter and summer hemispheres).

The instruments needed to achieve these objectives are: mass spectrometers, ultraviolet spectrometer, infrared atmospheric sounder, retarded potential analyser, and a Langmuir



Kepler spacecraft structure (with dimensions in mm).



The evolution of Kepler's orbit about Mars with respect to the bow shock and ionopause locations. The time lag between orbits 10 and 12 is two months.

ESA

probe. All are standard instruments with well-known properties and requirements, and have been flown by European scientists before.

Interaction with the Solar Wind

A primary objective of Kepler is to determine the nature of the interaction between the solar wind and Mars. Two types of interaction have been proposed: (1) an ionospheric Venus-like interaction in which the pressure of the atmospheric charged particles holds off the solar wind; (2) a magnetospheric Mercury-like interaction in which the pressure of the planetary magnetic field holds off the solar wind. Recent studies tend to support the idea that Mars' solar wind interaction represents an intermediate case between these two.

None of the spacecraft flown around Mars to date has had good instrumentation for measuring the magnetic field or the solar wind (Mariners 6, 7 and 9, and the two Vikings had no such instruments). Mars 2, 3 and 5 did not approach closer than 1,100 km and the information they did pick up suffered from a low 'bit rate' of return and gaps in the data (two to ten minutes long). The Soviet probes did detect a local magnetic field, and also - together with Mariner 4 - what appeared to be a bow shock in the solar wind flow close to Mars. But none of these craft directly sampled the region where the solar wind actually interacts with the upper atmosphere, ionosphere, or magnetosphere. Kepler will do so, using a plasma analyser, a plasma wave detector, and a three-axis magnetometer.

Surface and Interior Science

The study of Mars' internal structure and the dynamics of the interior has not been even a secondary objective of previous missions. These topics will be studied by Kepler through a better knowledge of the gravity field, a determination of Mars' topography, and a study of its magnetic field.

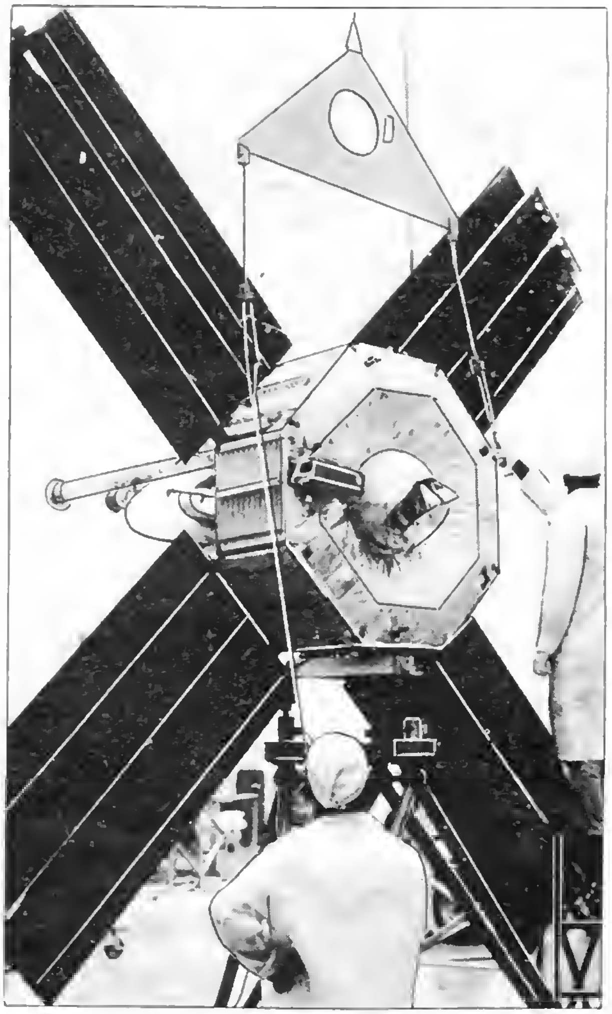
Two-way Doppler tracking data from the Mariner 9 and Viking missions has been used to compute a model of the Martian gravity field, and gravity anomalies directly associated with visible topographic features such as *Olympus Mons* and *Valles Marineris* have been discovered. The accuracy of these results depend strongly on the periapsis altitude (the lowest point of the orbit: Mariner 9, 1,500 km; Viking 1 & 2, 300 km) and also the location of the periapsis on the surface of the planet (Mariner 9's periapsis was within a few degrees of 23 degrees latitude; Viking orbiters had a periapsis covering from 45°S to 60°N latitude). Kepler will be a major step forward as it will have a periapsis as low as 150 km and will cover the entire surface. This gravity field experiment requires only good tracking capabilities.

So far, the topography of Mars has been inferred from pressure maps, occultation measurements, very rough ground-based radar observations and photogrammetric reduction of a few Viking pictures. These data suffer greatly from lack of coverage in the polar regions and overall poor accuracy. Kepler's contribution to topographic study will come through a radar altimeter; this will be the only instrument so far not flown by European scientists but it does have the characteristics needed by Kepler. However, enough experience exists such that its inclusion should not give rise to any worries. A 10 kg radar altimeter was flown on the Pioneer Venus Orbiter.

With Kepler, the opportunity of studying the magnetic properties of Mars is given high priority, and a magnetometer will be carried for this purpose.

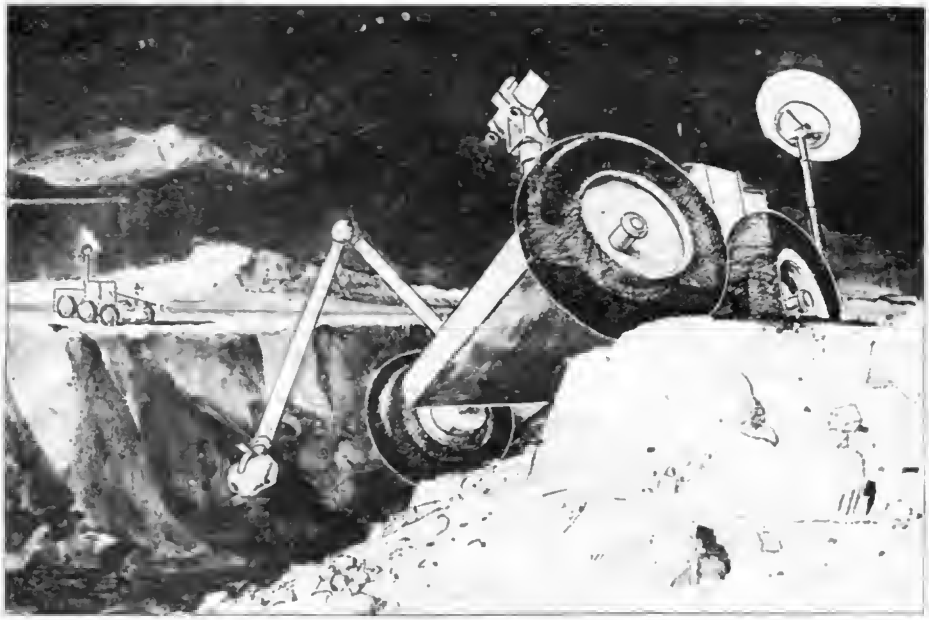
Spacecraft Design

Kepler, with a maximum diameter of 2.8 m, will be spin-stabilised (5 rpm) with a despun antenna. Tracking and data gathering in one revolution out of five (for which one Earth ground station, Weilheim in Germany, is sufficient) is considered scientifically satisfactory.



Mariner 4 provided us with our first close-up glimpse of Mars, followed by Mariners 6 and 7 in 1967. Mariner 9 mapped most of the planet following launch in 1971 and Viking emplaced two landers on the surface.

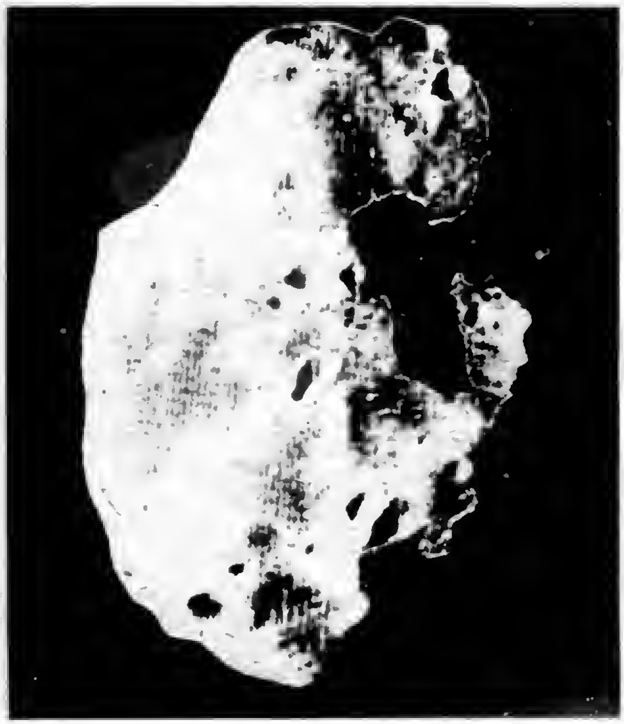
NASA



A concept studied by the Jet Propulsion Laboratory for exploring the surface of Mars as a follow-on to Viking. "Purple Pigeon" would use two rovers controlled via two relay orbiters. "The Martian Rovers", in the August-September 1981 *Spaceflight*, describes these, and other, concepts. NASA

Useful spacecraft mass in Mars orbit (i.e. excluding motor casing and remaining fuel) is estimated at 302 kg. The craft carries a bipropellant liquid motor for mid-course corrections, injection into Mars orbit, orbital modifications and spin control. The motor chosen is derived from an engine developed by MBB and successfully used in Symphonie and currently adapted as the Galileo retro-propulsion module. Kepler will also have ten small rockets for attitude control.

Powered by solar arrays of nearly 3 m², Kepler will have batteries to operate during solar eclipses. In order to reduce total power requirements several experiments will be automatically switched on/off each revolution.



This was the most detailed view of Phobos seen by Man when the image was captured by Mariner 9. NASA

Flight Plan

The mission can be broken down into four phases:

Launch and Trans-Mars Injection

Launch will be from ESA's Kourou Launch Centre in French Guiana, by one of two developments of the Ariane launcher - either Ariane 3, or Ariane 2 with a fourth stage. The latter allows a better weight margin, the fourth stage (for which it is proposed to use IDR, the IRIS Derived Rocket currently being developed by the Italians primarily as a perigee stage to fly with the Shuttle) allowing a useful spacecraft mass in final Mars orbit of 450 kg, as against 350 kg for Ariane 3 on its own (302 kg is the actual estimated mass under the present proposal). Launch opportunities to Mars occur approximately every two years and the mid-1988 launch window (centred around 17 July 1988 and lasting for about one month) is considered the most realistic, though a backup date in mid-1990 is possible, with very limited adjustment in the spacecraft configuration for the same scientific mission.

Cruise Phase

Kepler will be monitored for about four hours each day with the payload switched off during this period. Using the 1988 launch window means that the cruise will last about six months. No cruise science is proposed, though the mission could be expanded to provide a baseline in the ecliptic plane for solar wind and solar activity studies being made at the same time by the International Solar Polar Mission. A solar cosmic rays experiment could be added to the payload for this purpose.

Mars Orbit Insertion

The aim will be to establish an apoapsis of 6,300 km, periapsis being subsequently lowered to give an orbit of 6,300 km/200 km with an inclination of 80° and period of 4.8 hours.

Mars Mission Operations

Kepler will make five revolutions each day. The periapsis will move around the planet covering the entire surface twice in one Mars year. Kepler will be tracked for at least one Mars year (687 days), giving a planned mission time of 2½ years from launch. As during the other three phases, operations will be controlled from the Kepler-Mars Payload Operations Control Centre at ESOC (European Space Operations Centre) at Darmstadt, West Germany.

IUS UNITS DELIVERED

The first sections of the first Inertial Upper Stage (IUS) were delivered by Boeing to the US Air Force's Eastern Lauch Site in Florida last December. The IUS will eventually serve as an upper stage for both the Titan III and Shuttle vehicles, with the first launch atop a Titan 34D this year.

The items delivered were the IUS's equipment support section with all its avionics and other systems, and the interstage which will connect the two solid-fuel rocket engines.

The equipment support section houses systems for guidance and navigation, telemetry, electrical power, tracking and command. It contains some 300 connectors and 4400 wires which, in total, stretch almost five miles.

Redundancy and parts quality are the key to the IUS's reliability, estimated to provide each vehicle with a 98 per cent chance of success. For instance, the equipment support section houses two identical master computers, each of which, in addition to being capable of controlling the vehicle's mission, can isolate problems and circumvent them in milliseconds.

Other components which either have backup units or internal redundancy include guidance units, batteries, electrical power buses, antennae, telemetry units, inertial measurement units, signal conditioners and reaction control thrusters.

The two solid-fuel rocket motors, produced by the Chemical Systems Division of United Technologies, were delivered later for integration with the Boeing-built segments to complete the IUS.

SPACE TELESCOPE MIRROR COATED

NASA's Space Telescope has passed a major milestone in its development: the coating of the 94 inch primary mirror.

The Space Telescope, which will use two mirrors to focus light from stellar objects on to a group of scientific instruments at the rear of the telescope assembly, carries a 1800 lb primary mirror coated with aluminium three-millionths-of-an-inch thick.

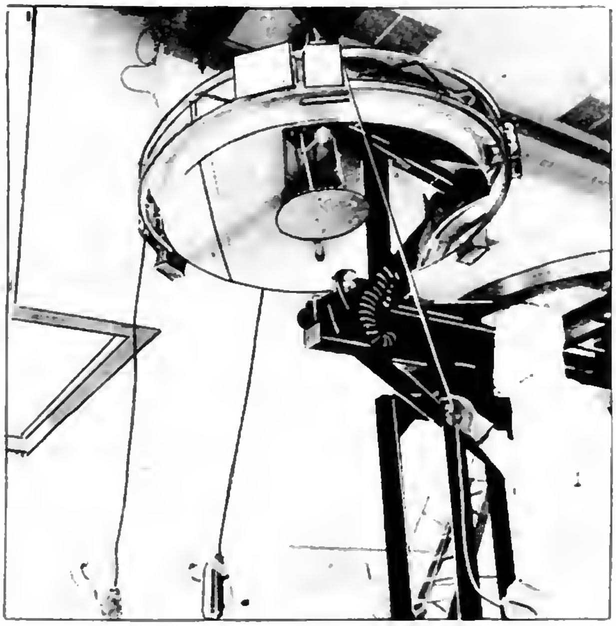
The Perkin-Elmer Corporation, responsible for the design and production of the optical assembly, completed coating the primary mirror with the highly reflective metal on 5 December.

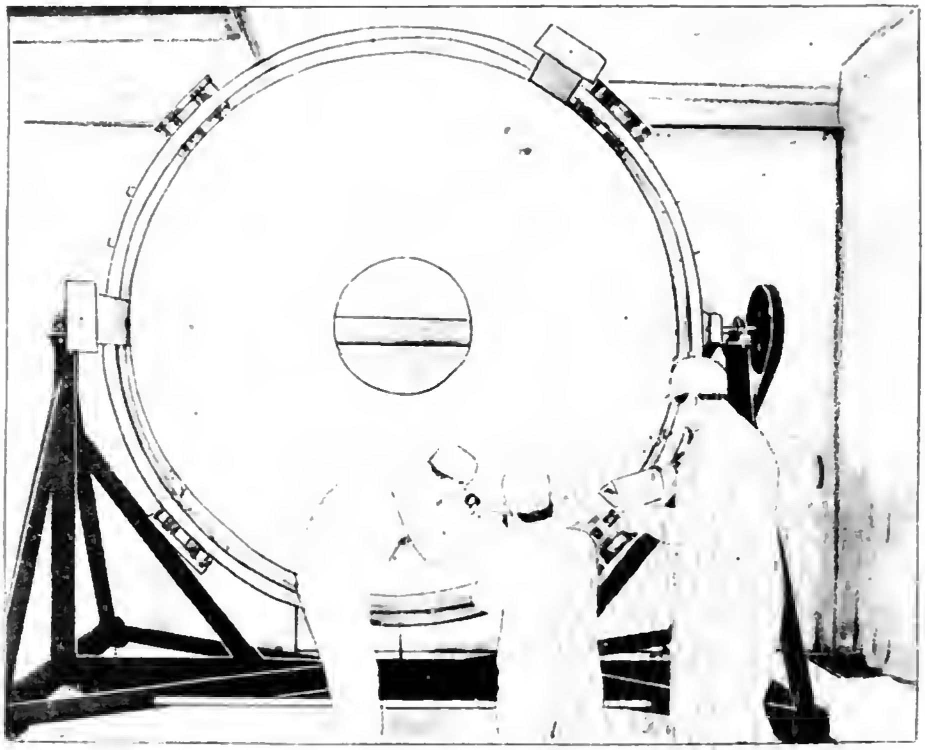
Engineers have since verified that the coating adheres to the mirror and has the proper reflectivity.

SPACELAB 1 CREW IN JAPAN

The Spacelab 1 payload crew travelled to Japan last December for training to operate a group of instruments scheduled to fly on the first mission of the spaceborne research facility in 1983.

These instruments, used in an investigation called Space Experiments with Particle Accelerators (SEPAC), are designed





Left: Optical engineers complete the meticulous cleaning of the face of the 94-inch primary mirror for NASA's Space Telescope, due for a 1985 launch, prior to its coating with a reflective surface. At this stage, the finely polished glass surface is still transparent, exposing the cellular construction of the mirrow blank. *Above:* the mirror after the coating process.

Perkin-Elmer Corporation

to help scientists gain an understanding of the Earth's magnetosphere and how it interacts with the upper atmosphere.

The crew spent time in classroom training and then practised operating the flight experiment hardware in a vacuum chamber at Japan's National Space Development Agency on the outskirts of Tokyo.

The payload crew for the first Spacelab mission (a joint NASA/ESA mission) consists of four payload specialists and two NASA mission specialist astronauts. They are Drs. Byron Lichtenberg and Michael Lampton of the United States, Drs. Ulf Merbold of West Germany and Wubbo Ockels of the Netherlands (payload specialists); and Drs. Owen Garriott and Robert Parker (mission specialists). Two of the payload specialists will actually fly aboard the mission with the two mission specialists, and two will support the mission from the ground.

SCRAMJET PROPULSION

One of the papers ("Characteristics of a Scramjet Orbiter" by Edward Lantz) presented at the IAF Congress in Rome last September described the form of a space transporter using hydrogen-powered scramjets. Scramjets promise to be efficient launchers for the future, partially because they have to carry no oxygen to burn with the hydrogen fuel. They will take oxygen from the air as they travel through it as high speeds (hence the term "supersonic combustion ramjet", or scramjet) but that also presents a difficulty: they have to be accelerated up to about 2 km/s *before* the scramjets can begin to operate.

Lantz described the use of two subsonic ramjets, each with a take-off mass of about 130,000 kg, which would take the main vehicle up to the required 2 km/s and then separate to return to Earth. The whole craft would be launched in the first place by a mechanical system from the ground so that the boosters' own ramjets could function.

Preliminary calculations show the two boosters to be 50 m long, with the 720,000 kg Orbiter 90 m long. Payload to a 161 km orbit would be 32,000 kg.

NEW SPACE LAUNCHER?

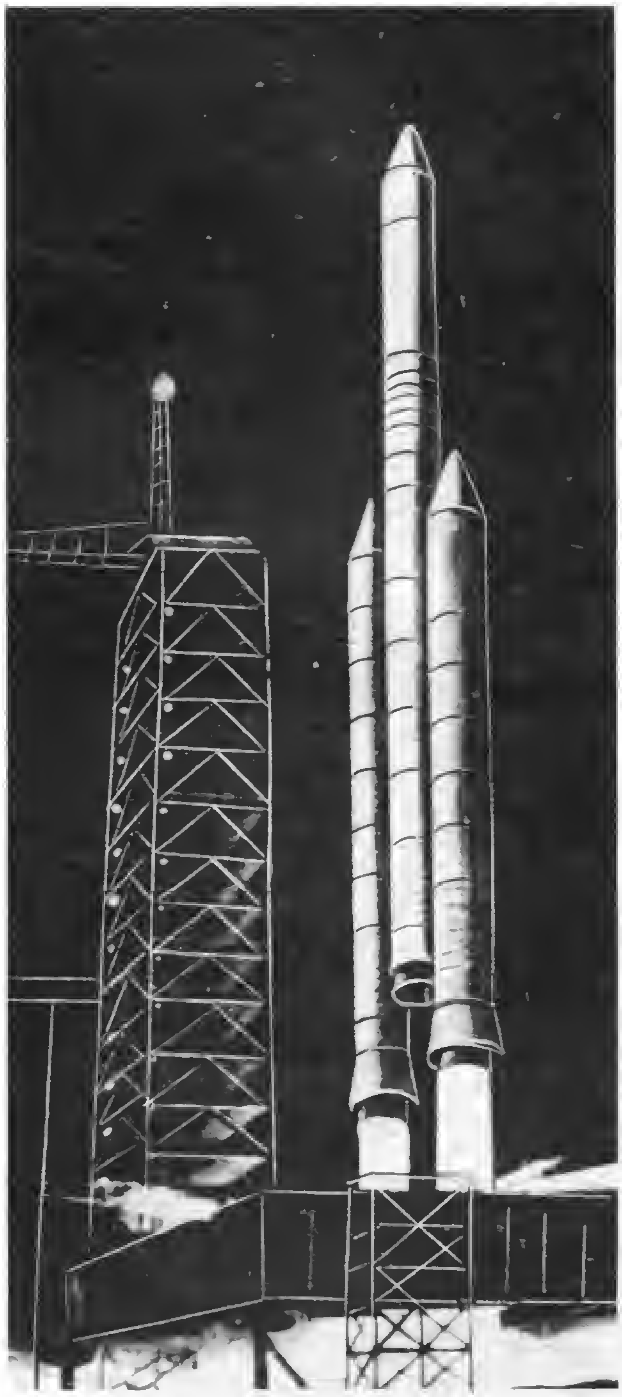
NASA is considering using some of the Space Shuttle's reusable features as part of an unmanned launch vehicle (mentioned briefly in last month's Shuttle report in *Spaceflight*). The Shuttle's recoverable solid rocket boosters (SRB's) would make up the major segment of a launcher being studied by the Boeing Aerospace Company.

Under a one-year, $250,000 contract with the NASA Marshall Space Flight Center, Boeing engineers are searching for a concept that would use the Shuttle's hardware and facilities with only minor modifications. Called the SRB-X, the proposed vehicle would use the solid rocket boosters, but not the Orbiter or external tank.

Although the Space Shuttle will be the primary launcher, it may need to share the load with another launch vehicle in a mixed-fleet operation. NASA is considering this idea because the Shuttle may have tight schedule requirements and payloads that may be too large or heavy when delivered to certain destinations.

The various SRB-X options being considered could deliver payloads weighing up to 65,000 lb to low Earth orbit (about 150 miles) or 12,000 lb to geosynchronous orbit. SRB-X would be tailored so that certain payloads could be interchangeable with the Shuttle and could be launched from Shuttle facilities at Kennedy Space Center or Vandenberg Air Force Base. This would allow for early availability and low developmental costs.

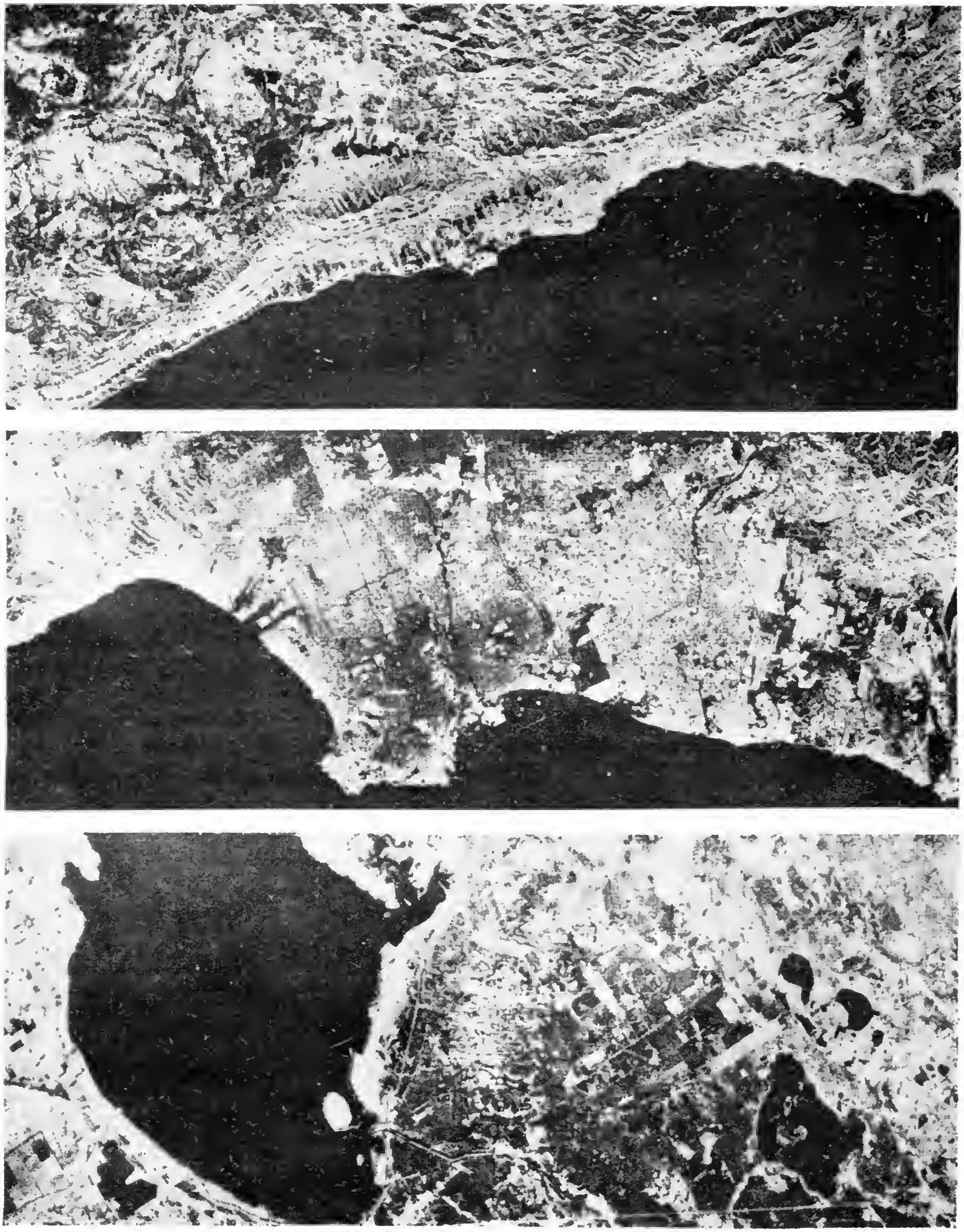
The contract with the space agency is divided into two study areas. During the first six-month period, Boeing will study a



One possible configuration for a space launcher built out of Shuttle SRB units.
NASA

large number of potential concepts using current or modified Shuttle boosters and selected upper stages. These concepts will be compared in terms of performance, mission utility and cost analysis. Upper stage and payload integration will be considered as well as ground operations and facility requirements. By the end of the phase, the engineers will have narrowed the field of options.

During the final six-month phase, the firm will define in greater detail those particular concepts that seem most promising and make a final selection and recommendation. The study results will then allow NASA to compare the recommended SRB-X concept with other Shuttle-derived concepts.

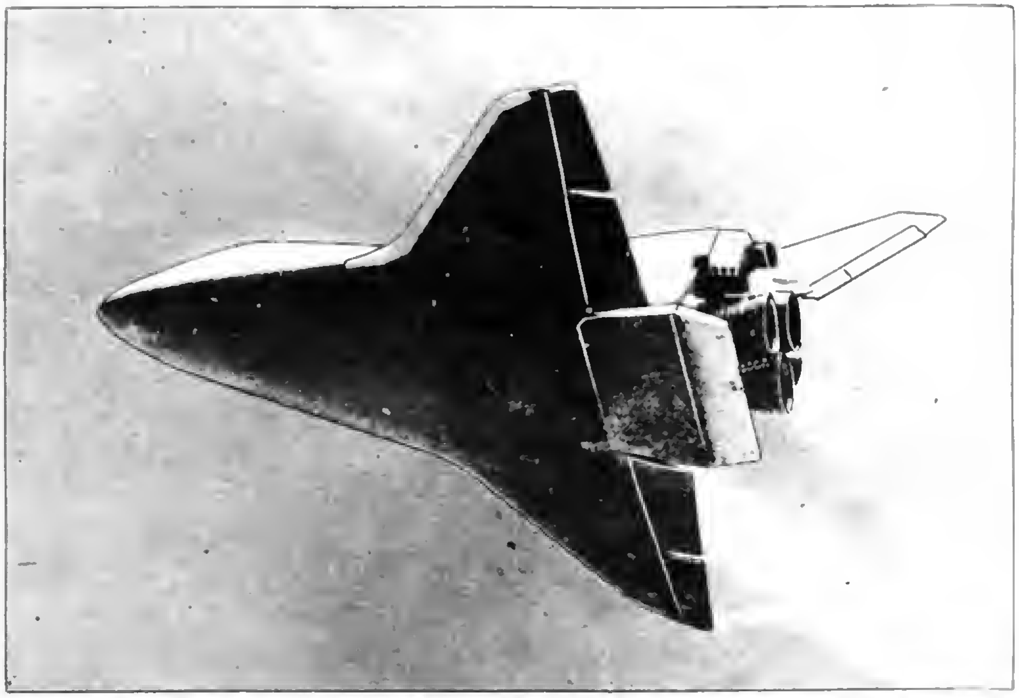


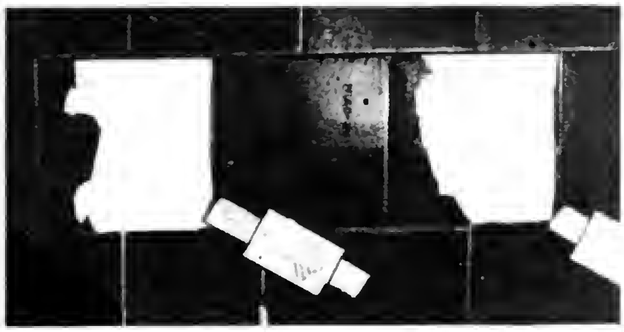
Three images from the Shuttle Imaging Radar (SIR) carried aboard the second Shuttle orbital flight. SIR was designed to test the potential of using spaceborne imaging radars as tools for geological mapping and Earth resources observations. The experiment obtained images covering 10 million sq. km, despite the shortened mission. *Top:* The Californian coast from Point Concepcion (right) to Ventura. The bright points in the sea are oil platforms (in a line) and boats. *Centre:* the Los Angeles basin, with vessels and harbour breakwater clearly visible. *Bottom:* the Lake Okeechobee area in the centre of Florida. Swamps and wetlands appear as very bright features.

NASA

The reentry of the Shuttle Orbiter *Columbia* during its second mission (right) produced a previously unseen type of damage to the thermal tiles (below right). Water from rain showers while *Columbia* was on the pad is believed to have soaked in and then turned to steam under the high temperatures of reentry.

NASA





MAGNETOSPHERIC "CLEFT"

NASA and the National Research Council (NRC) of Canada have launched off a series of sounding rockets in the Northwest Territories of Canada to study the dynamics of the cleft (wedge-shaped opening) in the Earth's magnetic field.

Five large rockets carrying some 30 experiments were launched into the pre-noon, noon and post-noon magnetospheric cleft region between 25 November and 21 December 1981. Events in this region can cause problems ranging from communications disruptions to pipeline corrosion, and, in ways not yet fully understood, influence long-term weather patterns.

The primary goal of the Cleft Energetics, Transport and Ultraviolet Radiation (CENTAUR) Project was a comparison of mechanisms responsible for the production of Birkeland currents (sheet currents of electricity running into and out of the ionosphere around the auroral ovals) and the associated energisation of charged particles in the pre- and post-noon magnetospheric cleft. In particular, the anticipated difference in the direction of the electric field downward on the morningside and upward on the eveningside implies different mechanisms involving different charge carriers.

The magnetospheric cleft is an opening between the Earth's magnetic field and the interplanetary field associated with the magnetic poles. Charged particles entering the Earth's upper atmosphere cause the airglow or aurora which occurs in this area. At this time of year, as the Sun approaches winter solstice and is below the horizon in this region, scientists can explore atmospheric conditions on the "Sun side" of the Earth as they appear in the dark from the ground.

The cleft offers a unique opportunity to study particle acceleration mechanisms in a regime which is less structured in space and time, as opposed to the highly dynamic nightside auroral region, yet is equally interesting and physically rewarding.

Data were acquired by an assortment of ground intrumentation and sounding rocket payloads. The rockets consisted of two Black Brant X, one Terrier-Malemute II, and two Black Brant IV.

Ground based instrumentation consisted of equipment installed at the launch site (Cape Parry) and Sachs Harbor, Banks Island, about 200 km poleward. The project also used other existing ground based instruments in the Arctic region, as well as data from Earth orbiting satellites, such as Dynamics Explorer and the International Sun-Earth Explorer Satellite.

MARS ORBITER

NASA has awarded RCA Astro-Electronics a $20,000 contract to perform conceptual studies for a Mars polar-orbiting spacecraft. The craft would provide global coverage of the planet for at least one Martian year, relaying data on the atmosphere (composition, etc) and surface variations.

The Mars Science Working Group of NASA recommended in the 1970's that a suitable follow-on to Mariner and Viking would be a "Mars 1984" polar-orbiting mission. ESA is also studying its own orbiter mission, Kepler.

KEY OF THE DOOR

At the conclusion of the STS-2 postflight press conference Astronaut Office Chief John W. Young presented ceremonial keys for *Columbia* to the crew of STS-3, writes Gerald Borrowman.

Jack Lousma described the mission of STS-3:

"This time we will be up approximately seven days (116

STS-3 crew Jack Lousma (left) and Gordon Fullerton. NASA

revolutions). And we will be doing essentially the same things that were done before but in addition there will be more work with the Canadian-built arm (the Remote Manipulator System). We will actually be picking up some payloads, and we have a really advanced scientific payload."

The payload known as OSS-1 (after the NASA Office of Space Science) is mounted on a U-shaped pallet, making up a 2,609 lb package. A drum-shaped experiment will stretch 45 ft out from the cargo bay attached to the end of the flexing robot arm. It will help engineers to discover just how rough a wake *Columbia* produces in its journey through an ocean of atomic particles.

The 4 ft-long box is part of a $20 million package of cameras, probes and computerised dust-catchers.

Not all of the monitors of this experiment package deal with inanimate atomic particles. Fullerton described the OSS.

"We have two payloads mounted in the payload bay, approximately 500 lb packages. We are planning to grapple those; that is, grab onto them with a fixture at the end of the manipulator arm, manoeuvre them to various positions outside the payload bay taking scientific and environmental measurements and bringing them back and reberthing them in the payload bay."

Fullerton added, "In the launch and entry area we are going to be expanding the envelope (by) flying a trajectory that is more demanding on the vehicle and paving the way for heavier payloads on later flights. And then during the re-entry executing additional manoeuvres to further understand the aerodynamics and handling qualities of the Orbiter during that phase of the flight. We will really be examining the full range of the capability of the manipulator arm, although not with its maximum capability."

Lousma squashed public reports in the aftermath of STS-2 that the third flight of Columbia would entail an EVA (extravehicular activity): "No unfortunately, we don't have any planned excursions outside the vehicle. Although we are prepared on a contingency basis for certain things that could become problems. There is no planned EVA on this flight. Well, I'd surely like an excuse to go on outside if we generate one. I'd look forward to it, but we are not planning it."

Commander Lousma provided an overview of crew activities for the third orbital flight test: "We certainly plan to sleep as much as required. But you find when you're up there that you have such a short opportunity to be there and you're not there that very often it's hard to go to sleep at night and you want to look out the windows to see the spectacular view. And so I think that some of the wake time is planned and some of it unscheduled, but we plan to use a sleeping bag on this flight and have one person sleeping at the controls. And we will try to maintain a more rigorous schedule as far as eating and sleeping are concerned.

"The second crew (Engle and Truly) told us that you had to plan more time for getting the meals ready and handling message traffic."

One of the many television sequences planned for STS-3 includes an attempt to film the thrusters of the Reaction Control System firing. John Young has previously described the firing of the forward RCS jets as "sounding like a muffled howitzer going off, with a blue flame shooting out about 40 ft." Television planners hope to be able to capture the same sort of sight if they are able to focus cameras on the systems.

HEAO 3 BURNS UP

HEAO 3, NASA's third and last in a series of High Energy Astronomy Observatories launched in the late 1970's, decayed from orbit on 7 December and burned up harmlessly in the atmosphere.

"Tracking stations indicate that it broke up into pieces over the South Pacific," said John Stone, HEAO Project manager at the Marshall Space Flight Center.

The first observatory, HEAO 1, re-entered in 1979; HEAO 2 is still in orbit but no longer operational. It was expected to re-enter this spring.

Launched in September 1979, HEAO 3 was designed to scan the sky to further our knowledge of cosmic and gamma rays. Although it was built for a mission life of six months, it continued to provide data until June last year when it ran out of attitude control gas.

The mission of HEAO 3 differed from its two predecessors, which were designed to study X-rays. Through the study of cosmic rays, HEAO 3 measured the relative abundances of elements in the Universe and found unexpected differences between these amounts and the relative abundances of elements in the Solar System.

NASA 1982 LAUNCH SCHEDULE

NASA planners have an ambitious launch schedule for 1982: 12 expendable vehicle launches and three Space Shuttle flights, including the first operational mission.

Of the 12 expendable vehicles, seven are Delta rockets, three Atlas Centaurs and two Scouts. One of the Deltas will be launched from Kennedy Space Center facilities at Vandenberg Air Force Base, Calif., and will carry the only non-communications satellite to be launched this year.

The launch scorecard for 1982 began in January with RCA-C' aboard a Delta. February saw another Delta, this one boosting Westar IV into orbit.

March begins with an Atlas Centaur rocket with the Intelsat V F-4 satellite, and near the end of the month the third Space Shuttle mission is scheduled.

April and May will have a Delta to launch Insat-1A and an Atlas Centaur for Intelsat V F-5. In June, a Scout rocket will launch a Defense Department Transit satellite from Vandenberg.

July will have two launches: an Earth resources satellite, Landsat D, aboard a Delta from Vandenberg, and the fourth Space Shuttle mission (STS-4) from Kennedy Space Center. In early August Telesat F (also called Anik D), a Canadian communications satellite, will be launched on a Delta rocket.

In late September, Westar V will be launched on a Delta. November will see the fourth Delta in a row, with RCA E as its payload, and will be highlighted by STS-5, the first operational mission of the Space Shuttle. That flight is listed as carrying two communications satellites, SBS C and Telesat E, and their boost stages plus an experiments pallet, OSTA-2. The mission is scheduled to last five days.

Also in November, the year's second Scout launch will orbit San Marco-D/L, a joint NASA/Italy project designed to study the relationship of solar activity to meteorological phenomenon.

NASA will supply the launch vehicle while Italy supplies the satellite which will be launched from Italy's San Marco launch site off the coast of Kenya.

The last launch of 1982 is now listed as an Atlas Centaur, carrying Intelsat VA F-1, the third Atlas Centaur-Intelsat combination for the year.

The Westars are being launched for Western Union, the RCA satellites are part of the RCA Satcom Network, the SBS series is owned and operated by Satellite Business Systems, the Telesats are being orbited for Telesat Canada and the Insat will be launched for India.

The communications satellite missions are classed as reimbursables, meaning that NASA is reimbursed for the cost of the launch vehicles and launch operations.

(Please note that the information given above is correct as of December 1981 - *Ed.*)

UK TELESCOPE

Grubb Parsons of Newcastle-upon-Tyne has been awarded a £3 million contract for the construction of the 4.2 metre "William Herschell" optical telescope (see *Spaceflight*, November 1981, p. 301).

When completed in 1984, it will be the third largest single mirror optical telescope in the world. It will be erected at the new Spanish Observatory on La Palma in the Canary Islands where it will join SERC's 2.5 m and 1 m aperture telescopes also made by Grubb Parsons and now being installed ready for early operation.

The mountain-top on La Palma has been shown by SERC scientists to be one of the best observing sites in the northern hemisphere. The need of several European nations to have access to such a good site led in 1979 to an international agreement between Spain, the UK, Sweden and Denmark to

MAJOR SPACE EVENTS OF 1981

12 Mar	Soyuz T4: Vladimir Kovalyonok and Viktor Savinykh launched on fifth long-duration Salyut 6 mission (75 days). Savinykh 100th man in space.
22 Mar	Soyuz 39: Vladimir Dzhanibekov and Jugderdemidiyn Gurragcha (Mongolian) launched on one-week Intercosmos visit to Salyut 6.
12 Apr	STS-1: first flight of US Space Shuttle. John Young and Robert Crippen launched on 2-day orbital flight test, on 20th anniversary of first manned space flight.
14 May	Soyuz 40: Leonid Popov and Dumitru Prunariu (Romanian) launched on final Intercosmos flight of the present series. One-week stay aboard Salyut 6. Last flight of "old" Soyuz.
19 Jun	Third test flight of ESA's Ariane launcher - Meteosat 2 and "Apple" successfully placed in geostationary orbit.
19 Jun	Cosmos 1267, launched 24 April, docks with Salyut 6, greatly increasing space station's size. Announced as "prototype space module" (?)
26 Aug	Voyager 2 sweeps within 160,000 km of Saturn, returning some 18,000 photos of the planet, its rings and satellites. Craft on course for rendezvous with Uranus (1986) and Neptune (1989).
30 Oct	Launch of Soviet Venera 13 probe, due to arrive at Venus 1 March 1982.
1 Nov	Launch of Venera 14, due Venus 5 March 1982.
12 Nov	*Columbia* becomes first manned spacecraft to fly in space twice after perfect second launch. Crew: Joe Engle and Richard Truly. Mission cut to 2 days.
19 Dec	Ariane successfully launched on final test flight: Marecs maritime communications satellite placed in geostationary orbit.

A. A. THOMSON

create a major new observatory to be known as the Roque de los Muchachos Observatory. Spain is providing the site and infrastructure and the other nations are constructing the telescopes. SERC's Royal Greenwich Observatory leads the British involvement.

SPACE PIONEERS HONOURED

Alan Shepard, first American in space and the fifth man to walk on the Moon, has been inducted into the International Space Hall of Fame in Alamogordo, New Mexico, writes Dave Shayler. Four other pioneering astronauts were also inducted at the same ceremony: Scott Carpenter (Mercury 7); Gordon Cooper (Mercury 9, Gemini 5); Walter Schirra (Mercury 8, Gemini 6, Apollo 7); and Virgil Grissom (Mercury 4, Gemini 3) who was honoured posthumously.

Also honoured were Charles Yeager, who broke the sound barrier in 1947, and 19th Century rocket pioneer Andreas Anton Frederick, a Dane who developed a rocket system after the bombardment of Copenhagen in 1897.

SPACE ATTITUDE SURVEY

Recently released raw data from a survey undertaken for the National Science Foundation in the United States in 1979 shows support for space research in that country, but also a degree of ambivalence towards the benefits and purpose of space exploration, writes James Sweeney. *Attitudes of the US Public Toward Science and Technology: 1979* is based on a survey of 1635 people conducted by the Institute for Survey Research at Temple University in Philadelphia.

Respondents were presented with a list of headlines of stories that have appeared in newspapers and magazines, and asked which ones they would be likely to read. Two questions concerned space. "Communication Satellite to Improve Telephone Services" would definitely be read by 15 per cent, probably read by 43 per cent, probably not read by 29 per cent, and definitely not read by 12 per cent, with 1 per cent other or not knowing. "Space Scientist Asserts Need for Manned Flight" would be definitely read by 13 per cent, probably read by 33 per cent, probably not read by 35 per cent, definitely not read by 17 per cent, with 2 per cent not knowing or other.

A question was asked on whether or not the respondent had read or heard anything about "controversies concerning the exploration of outer space"; 60 per cent had, and 40 per cent had not. When asked how much interest they had in these controversies, 15 per cent had a great deal of interest, 30 per cent some, 16 per cent a very little, and 40 per cent did not know or other. Respondents were also asked how well informed they considered themselves on the exploration of outer space. The study found that 9 per cent considered themselves well informed, 35 per cent somewhat informed, 17 per cent hardly informed, and 40 per cent didn't know.

Asked if "benefits are likely to come from outer space," 43 per cent said yes, 17 per cent said no, and 40 per cent either did not know or had other responses. When asked about possible "harmful consequences" from exploring space, 25 per cent said yes, 35 per cent said no, and 40 per cent either did not know or had another answer. One of the most frequently mentioned harmful consequences was "falling debris, leave garbage in space." The poll was conducted from October to December 1979, just several months after the Skylab space station fell from orbit, scattering debris over Australia.

Respondents were also asked, "in general, do you favour or oppose the exploration of outer space;" 60 per cent were in favour, 30 per cent against, and 10 per cent did not know or had other answers.

A question was also asked about the possibility of researchers discovering a way to put communities of people in space in the next 25 years. While 17 per cent thought that was very likely, 38 per cent thought it was possible, 42 per cent saw it as not likely at all, and 3 per cent did not know or had other answers.

A series of questions was asked on controversial areas which some people feel scientists should leave alone. One question concerned studies that might discover intelligent beings in space; 54 per cent felt that such research should be done, 36 per cent felt it should not, and 10 per cent did not know or had another response.

Preferences for allocation of tax revenues for various areas were polled in the survey. Respondents were presented with a list of 14 items, and asked which three they would most like to receive science and technology funding, and asked which three they would least like to receive funding. Categories were: improving health care, reducing and controlling pollution, reducing crime, preventing and treating drug addiction, improving education, improving the safety of cars, developing faster and safer public transportation within and between cities, finding better birth control methods, discovering new basic knowledge about Man and nature, predicting and controlling the weather, exploring outer space, developing or improving weapons for national defence, developing energy sources and conserving energy, and developing or improving methods for producing food. Exploring space was one of the three categories which should most get funding in 6 per cent of the responses, one of the three least favourites in 43 per cent, and not mentioned by 51 per cent. It tied with "finding better birth control methods" as the top-vote-getter for "least like to receive funding." It should be remembered when looking at the above figures that the poll was taken before the 1980 election and the recent drastic cuts in the government budget.

IN THE PAST

25 Years Ago . . .
April 1957. Studies began this month by the US Army Ballistic Missile Agency at Redstone Arsenal into the possibilities of using a large, clustered engine vehicle, generating 1.5 million pounds thrust, as part of a related family of space boosters. The Saturn family was born.

20 Years Ago . . .
15 March 1962. It was officially announced that Deke Slayton, then prime pilot for Mercury MA-7, would be replaced by Scott Carpenter. He was removed from flight status because of a minor heart flutter; it would be ten years before he was declared fit enough to gain a seat on another spaceflight.

15 Years Ago . . .
22 March 1967. X-15 pilot Michael Adams flew to a maximum altitude of 133,100 ft at a peak speed of 3822 m.p.h. (Mach 5.59). It was the 177th flight in the series and the third for Adams. Tragically, on his seventh flight in November 1967, he was killed in the crash of the third X-15 craft.

10 years ago . . .
6 April 1972. NASA and the National Science Teachers Association jointly announced the selection of 25 finalists for the Skylab Student Project as part of a NASA programme to stimulate student interest and participation in space research.

5 Years Ago . . .
14 April 1977. NASA awarded two contracts to McDonnell and Hughes for study reports as part of preparations for the proposed Jupiter entry mission in 1984, now named Galileo.

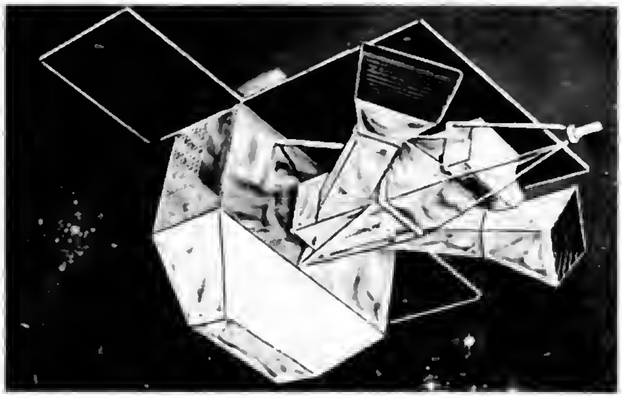
D. J. SHAYLER

HIPPARCOS: EUROPE'S ASTROMETRIC SATELLITE

By Neville Kidger

Astrometry: "The branch of astronomy dealing with the geometrical relations of the celestial bodies and their real and apparent positions."

Dictionary and Handbook of Aerospace
Bantam Books, 1969.



Hipparcos, the astrometric satellite. The two "arms" protruding from the central column provide the separate fields of view for measuring the positions of stars.

ESA

Introduction

In 1967 Professor Lacroute proposed that a satellite devoted to astrometry should be flown. Although rejected by the French Space Agency, CNES, for cost reasons in 1970, the project was eventually proposed to ESRO's scientific body and from there the project was finally adopted by the European Space Agency in 1980. Instrumental in the resurrection of the project, in 1973, was Professor Kovalevski.

ESA has defined the mission of the astrometry satellite as "the determination of the trigonometric parallaxes, proper motions and positions of about 100,000 stars, most of them brighter than magnitude 10." The data obtained will be used by astrometrists to construct an accurate, coherent, stellar reference frame with many fundamental uses for astronomers. The project is christened HIPPARCOS.

Why?

It might be asked, in these days of high performance satellites investigating the sky in the radio, ultraviolet, X-ray and gamma ray wavelengths, why should the need exist to develop a purely astrometric survey satellite?

Astrometry is the only one of the fundamental astronomical sciences which has yet to benefit from spaceflight techniques. Even the developers of the project admit that astrometry in general has failed to keep pace with the advances in other spheres of astronomy. In a report for ESA, Dr. M. A. C. Perryman of ESTEC confided that astrometry would appear, to all intents and purposes, to have stagnated and as a consequence would appear to be a dull subject. "To many I suspect it also appears to be all but pointless," Perryman writes, "and the dedicated astrometrists are seen as an ideosyncratic breed, fastidiously measuring the position of long lists of stars, arguing endlessly over irrelevant discrepancies in their final decimal places." Perryman concludes by saying that a glance at the available astrometric catalogues would put all but the most dedicated scientists off related aspects of stellar research.

Traditional methods

In the past, astrometry data has been gathered from ground-based observatories over long periods and compiled into catalogues of stars listing their individual positions, trigonometric parallaxes and proper motions. The science has developed into two branches: *Global* and *Local* astrometry.

Global astrometry seeks to measure large angles over the sky with, for example, meridian instruments using the diurnal rotation of the Earth and accurately calibrated circles. This type of observation provides data for the primary reference frame for stellar positions and proper motions.

Local astrometry is confined to small areas of the sky which can be photographed with astrographs (about 5° x 5°) or by long focus telescopes (about 1° x 1°). This method provides *relative* trigonometric parallaxes.

In order to define the position of a celestial body on the celestial sphere, the astrometrist must define the trigonometric parallax (by measuring the apparent shift in its position over a period of six months in order to use the biggest baseline available, the Earth's orbital diameter) the proper motion (the measurement of the star's movement through space over a given period of time) and position on the celestial sphere (in Right Ascension and Declination). Measurement of stellar positions from the ground is far from easy. The apparent shift of a star at 1 parsec (3.26 light years) away from the Earth is 1 arcsecond or 1/3600 th of one degree. The Moon has an apparent diameter across the sky of ½°.

The name Hipparcos refers to a Greek astronomer (190–120 BC) who, by measuring the position of the Moon against the stars, determined the Moon's parallax and thus its distance from Earth as 30 times the diameter of the Earth – the correct value. He also made the first accurate star map which led to the discovery, when compared to other data from his predecessors, that the Earth's north pole rotates in the sky, giving rise to the "Precession of the Equinoxes.

Hipparcos is also an acronym for **HIgh Precession PARallax COllecting Satellite.**

Current data

Global astrometric data is available in a fundamental catalogue, with the current edition called FK4, which was published in 1963. The FK4 gives data for about one star every 5° x 5° section of the sky. The catalogue lists stars above magnitude 7.5 and is the synthesis of observational data obtained with meridian instruments over more than a century from many ground based observatories. The mean epoch (or the date at which the coordinates for a celestial body are referred) of the FK4 is around 1930. With the passage of the years, the accumulated error in the astrometric position defined in the catalogue at 1980 was about 0.1 arcsecond for a single coordinate. Data for the southern hemisphere is relatively less accurate because of the relatively short historical observation time in that hemisphere.

By 1985 the FK4 will have been superseded by the FK5 which will list one star for every 3° x 3° section of the sky. Other catalogues, with varying degrees of error, are available to the astronomer but the problem still remains that large random errors occur in the realisation of the reference frame in a small region of the sky, say 1° x 1°, and there is an inhomogeneity of the systems of positions and proper motions between the northern and southern hemispheres.

The limiting factor in ground based astrometry is, of course,

our turbulent atmosphere. For Global astrometry the practical limits set by the atmosphere – 0.1 to 0.2 arcseconds of error – have already been achieved. Expected improvements in the future are in terms of efficiency and systematic accuracy. Improved meridian circles, currently being developed, will benefit from the reference frame which it is hoped the Hipparcos satellite will produce. By the end of the 1980's, automatic meridian circles should be providing astrometric data on about 200,000 observations per year with a mean error of 0.2 arcseconds.

Emphasis for these observations will probably be placed upon fainter stars and Solar System objects.

Radio telescopes (using the technique of Very Long Baseline Interferometry) are able to provide accurate position data. Observations of pulsars can also yield accurate position data comparable with that from the visual techniques. However, when the relative positions of faint optical sources can be measured with the Space Telescope (ST) it will be essential to have a coherent whole-sky reference frame to match the high precision of the ST itself. This is where the data from the Hipparcos satellite will come into its own.

Expected yield

In its geostationary orbit, high above the atmosphere, in a constant thermal environment and taking advantage of weightlessness, the Hipparcos satellite will be conducting essentially a Global astrometric task. ESA has anticipated that the satellite will operate for 2.5 years (although it will carry consumables for 4 years) and expects that it will provide data to achieve the following:

- Accuracy (stars above magnitude 10):

positions:	0.002 arcsec (this compares with the current best of 0.04 arcsec)
proper motions:	0.002 arcsec per year (comparable with the best ground observations after 50 years of observations
parallaxes:	0.002 arcsec (present 0.01 arcsec for bright stars)

- absolute parallaxes instead of relative
- systematic errors less than 0.001 arcsec, compared with present errors of 0.005 arcsec for parallaxes and 0.004 arcsec for positions
- large numbers of stars catalogued (100,000 compared with a few thousand in the most current catalogues)
- faint stars: down to magnitude 12 (presently 7 for best positions and proper motions
- homogenous sky coverage. In particular, a firm connection between the northern and southern celestial hemispheres.

With a density of about 2.5 stars per 1° x 1° and a standard error at epoch of observation of ± 0.002 arcsec (even after 10 years accumulated proper motion error, the error in a stellar position will be only ± 0.02 arcsec meaning that the error would need 100 years of accumulation to reach the same error as for present ground based data) the Hipparcos reference frame of proper motions will be referred to an inertial frame through the measurements of the apparent proper motions of extragalactic objects. This can be achieved by utilising the astrometric possibilities of the ST or large ground telescopes.

Among the benefits which astronomers expect to derive from the data provided by Hipparcos are: study of the motions of planetary and Solar System bodies, geodynamics, calibration of extragalactic distance scales, luminosity calibration of intrinsically bright stars, binary star mass determinations, study of stellar kinematics, and determination (to an error margin of less than 10%) of the parameters of the galactic model.

Data collection

The basic observation principle adopted for the Hipparcos satellite envisages the continuous and systematic scanning of the sky with a telescope with two fields of view capable of accurately measuring large angles between widely separated stars. Numerical combination of several millions of such angle measurements, to be collected over the 2.5 year lifetime of the satellite, will allow astrometrists to derive astrometric parameters of the selected target stars.

The telescope is based on an all-reflective Baker-Schmitt system in which two fields of view are separated by an angle of 68.5° on the celestial sphere. The two fields are focussed onto a single focal plane assembly containing a complex mirror, modulating grid and a dectector called an Image Disecting Tube (IDT). The IDT uses a photomultiplier to detect the photons of light emitted by the stellar object under scrutiny.

The size of each field imaged by the telescope will be 0.9° x 0.9°. By suitably controlling the attitude of the satellite, the two fields of view will continuously scan the whole celestia sphere with any particular point of the sky entering both fields several times per year. On average, ESA anticipates that four to five designated target stars will be viewed at any one time by the telescope.

During periods when the telescope has as many as four or five target stars in the field of view, the stars will be detected individually by an Instantaneous Field of View (IFOV) detector in which the detector rapidly switches from star to star. The amount of observing time given each star in the IFOV will depend upon its magnitude and designated observing priority. An average star will be observed as many as 100 times during the nominal lifetime of the satellite.

Flight plan

ESA anticipates that the satellite-weighing some 486 kg once in orbit – will be launched in late 1986 by an Araine variant.

At the apogee of an early revolution the MAGE 1S Apogee Boost Motor will be fired to circularise the orbit at 36,000 km altitude – a Geostationary orbit at a location suitable for 24 hours per day contact with the selected ESA European ground control station. Inclination will be less than 3° to the Equator. After the ABM firing, the satellite will be despun under gyro control and the solar panels deployed, the Sun and Earth acquired by their respective sensors and, by means of a hydrazine jet system and reaction wheels, the satellite will be started upon the slow scanning motion.

The catalogue

A successful mission will yield astrometric data for 100,000 stars down to the 13th magnitude, with errors of a few milliarcseconds. The computations to arrive at the final Hipparcos catalogue showing the two spherical components, two annual proper motion coordinates and the trigonometric parallax of each star observed will probably be done by two independent scientific teams in order to control efficiently what influence may occur due to different choices of method. The two teams will be allowed close contact to a degree which will not hinder them conducting their independent scientific responsibility. About 6 to 10 years of work is foreseen before publication of the final catalogue. The proposers of target stars will be allowed first access to the completed data.

Astrometry is set to join the space age.

Acknowledgements

The writer would like to thank the staff of the ESA Scientific Directorate, Press Office for their help.

THE U.S. AIR FORCE TEST PILOT SCHOOL

By Curtis Peebles

Introduction
When the selection process for the first group of US astronauts was begun, in late 1958, one of the requirements for selection was to be a graduate of a test pilot school, either the Air Force or the Navy. In the two decades since then, it has been a truism that if there is a sure path to selection as an astronaut, it is to have a test pilot background. Of the 56 pilot astronauts selected between 1959 and 1969, over half were test pilots. Of the two schools, the Air Force Test Pilot School is the older having celebrated its 35th year of operation in 1979. This article seeks to examine its curriculum and the reasons why test pilots are so often selected as astronauts.

Present Curriculum
If one was to compare the test pilot school to a college course, the nearest would probably be a PhD in flying. The school combines the most demanding parts of college and pilot training. Two classes are conducted a year with approximately 25 students in each. Two-thirds are pilots, the rest are flight engineers/navigators. Most are Air Force personnel but each year, there are several civilian, Navy and foreign students. In picking students, the selection board concentrates on three areas.

First is flight experience. The school seeks students with time in several types of aircraft. An informal guide is five different aircraft (not including training aircraft). The total number of flying hours and the ability to handle unfamiliar situations is, also, important. The second area is officer qualities such as honesty, self-discipline and a high efficiency rating. And finally — education; a degree in engineering, math or a physical science is among the requirements. The selection board looks at both the subjects covered and the grades achieved. The school looks at such things as efficiency reports and promotion records. They, also, seek letters of recommendation from people the prospective students have flown with; preferably test pilots but, also, squadron commanders.

After the tentative candidates are selected, they are brought to Edwards Air Force Base; they tour the school and make five evaluation flights with instructors. This is to determine their suitability. If they pass this test, they begin the 46 week course. This careful selection insures that both the most qualified students are selected and keeps the wash-out rate to only 2%. The typical student is a Captain, 31 or 32 years old with nine years in service and 1500 hours flight time. About half have Master degrees; the other have taken at least some graduate courses. Approximately 80% are married. By the late 1970's, only a small percentage had any combat experience. During the mid-part of the decade, it was almost 100%. The students could be described as achievers, finishing high in their flight training and winning awards. Most had wanted to be test pilots since childhood.

The curriculum is divided into three approximately equal parts — performance, flying qualities, and systems tests. With only a few exceptions, the pilots and the flight engineers take the same academic courses. The major difference occurs in the flight curriculum.

Performance Phase
The first phase covers aircraft performance. During the 11 week course, the students cover such areas as pitot static systems, take off and landing, climb, acceleration, turning performance, cruise, range and propulsion. The instructions cover three basic areas — theory, flight test techniques and flight curriculum. The instructors are all graduates themselves; the highest percentage of any western test pilot school. The classroom lectures first cover the theoretical aspects of a particular test often on a highly mathematical basis.

Next, the flight test techniques are covered. This is essentially a mass briefing of the class on how a test is to be done. It covers such things as altitude, speed, radio call signs and data analysis. The students are, also, cautioned about any hazards. An instructor then makes a check flight with the student; the instructor demonstrates the test and has the student practice it. The student learns to fly with a precision and skill he never before thought possible; such as controlling air speed to within half a knot or holding the aircraft in level

Graduates of the Test Pilot School can look forward to new challenges. Here, Joe Engle (left) and Dick Truly, pictured at the time of the *Enterprise* drop-tests, became the second Shuttle orbital crew.
NASA

flight even while accelerating through supersonic Mach numbers.

After the student is certified, a data flight is scheduled. Flying is done in the morning. After the first period of flying, the aircraft are re-fuelled and any necessary maintenance is done. A second period of flying is then undertaken. The aircraft (T-38, F/RF-4, KC-135, A-7D) are drawn from those assigned to Edwards Air Force Base. Unlike earlier years, the aircraft are not now assigned directly to the school. Classroom lectures begin at 1.30 p.m. and run for three hours. For some tests, the pilot is teamed with a flight test engineer. During the mission, the engineer operates the data recording equipment switching it on and off at the proper times thus reducing the pilot's workload; he also monitors the quality of the data. The data, recorded on multi-channel magnetic tape, vary from one test to the next. An example might be angle of attack, temperature, speed, altitude and control position up to about 40 channels in all. The pilot also records information on a knee pad and a voice recorder.

The tape cassette is taken to the school computer for data reduction. Use of magnetic tape is a comparatively recent change in procedure. From the school's founding in 1944 until the mid-70's, the data were recorded on film and/or oscillograph paper. In the first method, the aircraft carried a duplicate instrument panel which was photographed in flight. After the film was developed, the student would transcribe, by hand, frame by frame the instrument readings. The oscillograph paper is a long strip chart on which the various characteristics are recorded. It was hand transcribed. The data was then "normalized". It was mathematically converted to standard conditions (temperature, air pressure, gross weight, etc.) and plotted on charts and graphs, a long tedious process now done by computer. All that is required now is to configure the computer for the required program.

If the tedium is eased for today's student, he must do more tests than his predecessor, so it evens out. The data are then analyzed by the students and assembled into a report. The student looks at how well the results conform to theory. And if not, why not; was it good data and what does it all mean?

After the report is turned in, it is reviewed by the staff on several levels. First, in regards to format (margins, spacing, etc.). Then the student is graded on how well he communicates the information; then on how well the student learned the particular test. And finally, how well the data was analyzed. At the completion of the project, it begins all over with another series of theory, flight test techniques, etc. The performance phase includes a performance evaluation of either an A-37, T-38 or an F/RF-4.

The students are divided into data groups, four to six students per aircraft. Each student makes all the data flights. After they have been completed, the students pool their data to assemble a written report. The tests for this phase have a rigid standardized format. Data are pooled to insure accuracy and statistical relevance. This evaluation is identical to that done on a prototype aircraft.

The course requires a tremendous amount of sheer hard work. The students must put in long nights and week-ends at data reduction and study. It is not unusual for students to go to the school at 2 a.m. to run their tapes. It is often an around-the-clock schedule. At any one time, a student will be studying the day's lecture, reducing data, writing a report, studying an aircraft handbook and reviewing for a test. The grind takes its toll. The students are compulsive achievers; they want and need success. They drive themselves to do better. This puts stress on both the student's personality and his relationship with others. In an attempt to reduce the grind, there are 2 one-week free periods and field trips to the Navy Test Pilot School and contractor facilities. There is so much for the student to do, their wives are warned, at the start of the course, that for the duration, they will have to run the house and take

The Test Pilot School's curriculum was modified in 1961 to include training for space flight. These are the men of the first two groups selected to fly the USAF's Manned Orbiting Laboratory. Left to right, back row: Taylor, Neubeck, Lawyer, Crews, Macleay, Finley, Truly (STS-2 astronaut); front row: Crippen (STS-1 astronaut), Overmyer (Shuttle astronaut), Bobko (Shuttle astronaut), Fullerton (STS-3 astronaut), Hartsfield (Shuttle astronaut).

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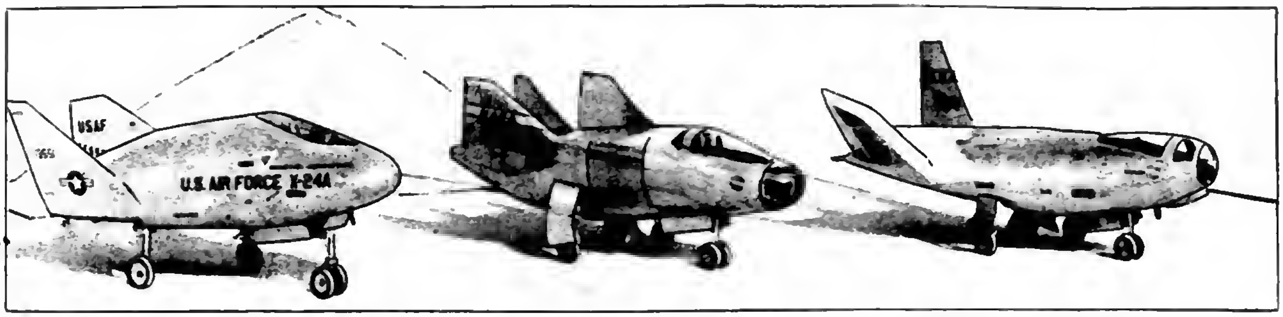


The NASA/Air Force series of experimental lifting bodies (*l. to r.*: X-24A, M2-F3 and HL-10) flew between 1965 and 1975. The resulting data helped in designing the Shuttle Orbiter.
NASA

care of the kids exclusively. If they need a shoulder to cry on, they are told to see one of the instructor's wives. They have all been through it before.

Flying Qualities Phase
The second phase is a more complicated one — duration is 18 weeks including one free week. The flying qualities phase, like the first, is divided into theory, flight test techniques and flying curriculum. Flying qualities is a more extensive field than performance, covering the aircraft's behaviour in flight and the pilot's control over it. This, in turn, relates to the aircraft's overall effectiveness. During the theory section, a particular emphasis is placed on the mathematics of aircraft handling. The students cover vectors and matrices, operational math and equations of motion. The course covers how various factors interplay to affect aircraft behaviour.

The differential equations of motion describe the behaviour of all aircraft. But because of the design of each aircraft, certain terms will have more importance than others. Also covered are stability, high angle of attack, engine out, manoeuvring, flight dynamics and operational handling. The flying curriculum makes use of both conventional aircraft (A-37, T-38, sailplanes, KC-135 and F/RF-4) and variable-stability aircraft such as a B-26 and T-33, outfitted as variable stability trainers.

As with the performance phase, the classes are again divided into data groups to conduct flying qualities test programmes on an A-37, T-38, A-7, F/RF-4 or KC-135. Each data group flies only one aircraft. Students fly a different aircraft than the one assigned in the performance phase and also work with different people. Each data group evaluates its assigned aircraft using military specifications. This document covers all facets of aircraft handling and rates each as either level 1 (completely satisfactory), level 2 (has deficiencies) or as level 3 (unsatisfactory). The ratings cover such areas as handling qualities, stability and manoeuvring.

There is an important difference in the flight testing. During the performance phase, the tests were rigidly detailed. During the flying qualities phase, the students are given a list of limitations. The students have more responsibility for flight test and planning. After the data groups have completed their tests, a report is assembled. It is given in an oral briefing to an audience of staff and guests. The school places great emphasis on communication skills. The staff believes that information is useless unless it can be effectively communicated. The briefing covers how well the aircraft can perform its mission. An aircraft may have excellent performance but if it is unstable, or the demands it makes on the pilot are excessive, it is both dangerous and useless. The question is: Will this or that poor flight characteristic be detrimental or is it not important? With these questions answered, the student moves into the final phase of the course.

Systems Phase
The third phase is a recent addition. It replaced the space studies phase when these were discontinued in late 1971. For ten years, the Aerospace Research Pilots School, as it was then known, included courses in space technology and science. However, with the cancellation of the Air Force's Manned Orbiting Laboratory (MOL) and the winding down of the Apollo programme, it was decided to re-emphasize the traditional aspects of test piloting. Because of the advances in aircraft systems, a separate phase was developed to cover this area. The duration is 19 weeks including one free week and a two week field trip. This phase covers the broadest area, virtually everything that can be put in or on an aircraft. The result is several changes in format from the previous sections. A test management section is added to the theory, flight test techniques and flying curriculum. Also, there is not the same kind of direct relationship between the sections. The test management covers aircraft modification, systems safety, range facilities, light aircraft, reliability in maintenance, all weather testing and system acquisition. Theory courses cover human factors, stores certification (external equipment, bombs, drop tanks, etc.), radar, electronics, electro-optics/displays, navigation, braking/anti-skid systems, advance simulation and closed loop handling qualities. These differences are due to the almost endless varieties of potential tests. They can range from as complex as an advanced low light level TV system to a new radio antenna. One part of the flying curriculum is a low lift-to-drag landing demonstration in a T-38. Two profiles are flown: one simulates the X-24 lifting body, the other the Space Shuttle.

The major emphasis, measured by relative flight time, is the qualitative flight evaluation of unfamiliar aircraft — some ten to fifteen hours for pilots and six hours for engineers. These aircraft, which the students have not flown before, are brought to Edwards Air Force Base along with squadron personnel. The students decide what areas they wish to test. The test plans are reviewed. The staff tries to borrow about 25 aircraft. A

September 1962: Air Force Secretary Eugene Zuckert with a Dyna-Soar mock-up. Dyna-Soar was the first attempt at developing a reusable shuttle spacecraft.
USAF

tentative list for class 79B includes F-15, F-111, F-106, B-57, U-2, C-141, Navy aircraft such as the P-3, helicopters and even the Goodyear blimp. After the tests, the student submits a two page report on each aircraft. The purpose is to familiarize the student with a wide range of aircraft and their characteristics, and to make him comfortable in an unfamiliar aircraft so that test flights can be made with a minimum of preparation. Because the aircraft must be borrowed, getting them can be a problem. Older aircraft are few in number; also, squadron personnel with a "scarf in the breeze, dive them until the wings fall off" view of test pilots can be reluctant to send them precious aircraft. A series of letters and phone calls is needed to reassure them.

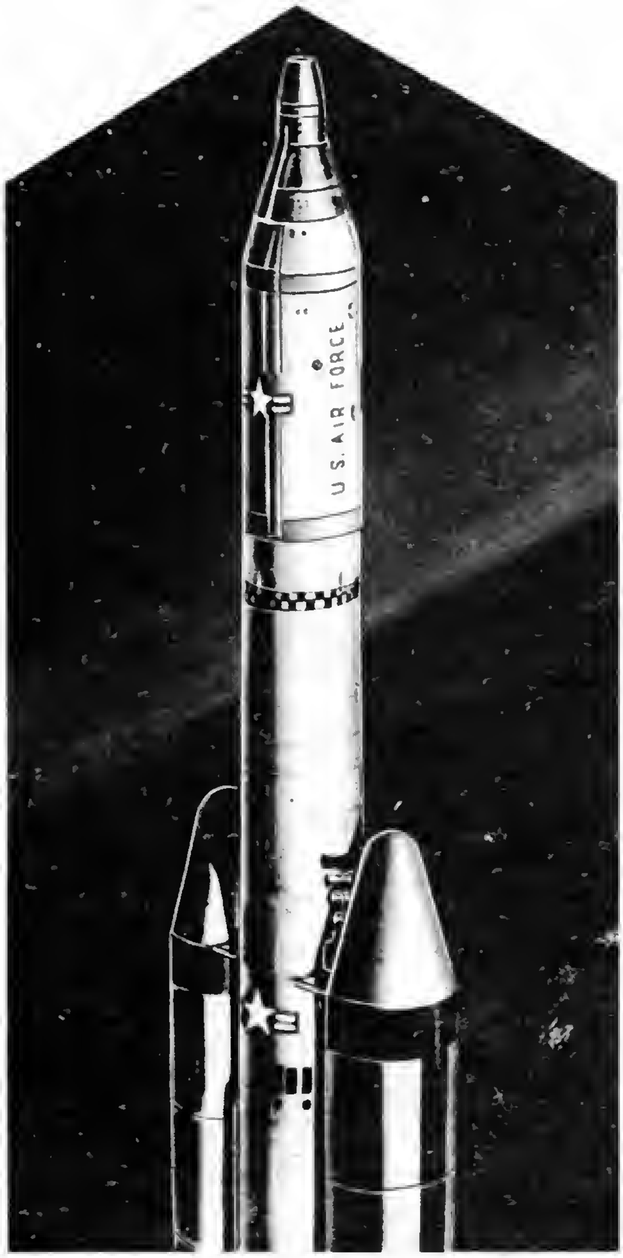
Students for the systems phase are once more divided into data groups. Each data group is assigned a project. These projects come from throughout the Air Force and civilian agencies. They are similar to the missions the students will undertake after graduation.

The data groups plan the flight tests. They then present an oral briefing to the staff. The plans are reviewed by the base safety officer. Once approved, the tests are made and the data reduced. The results are presented in both an oral briefing and a written report. The students have full responsibility for all facets of the class project. There are six projects assigned to Class 79B. One is the evaluation of an NT-33 equipped with a side stick controller. The project seeks design information for future systems. Another project will determine the effect of a fly-by-wire control system of a modified A-7 on gunsight accuracy during manoeuvring. One data group will conduct a weapon's certification for a low level bomb drop profile on an F-4. A fourth project will determine if an aft centre of gravity on a KC-135 will result in a saving of fuel. Even 1% improvement will save millions of dollars. This same group will also conduct a test of the KC-135's climb performance with one engine out. The fifth project is to develop curricula for use by the school for engine out training. The data group will use a UV-18 Twin Otter. The last project is an FAA sponsored study of aircraft altimeter accuracy using a T-38. This is aimed at determining the feasibility of reducing the separation of jets at high altitude.

Most of what the test pilots will do will be this type of follow-on tests — filling in the blanks in the knowledge of an aircraft. And so, after 11 months of hard work, long nights and endless study, the graduate has the satisfaction of a difficult job well done.

After Graduation

It is best to think of a test pilot as a scientist conducting a controlled experiment. The result will be a series of data points which will be used to graph a curve. The pilots conduct real time analysis. They are trained to feel changes in aircraft behaviour that represent the curves in the graph. The pilots concentrate on flying at these points of change to better define them. The test pilot must be skilled to be able to reproduce the flight characteristics on a reliable basis. He must, also, be a skilled engineer to be an effective part of the design team. Yet this is not the reason the school is so selective or the curriculum so difficult. To be effective, the test pilot must have, in addition to these qualities — judgment. Any competent engineer can develop an endless variety of procedures to deal with a particular situation, each tailored to a narrowly defined set of variables. The test pilot must judge which is the ONE best procedure based on the total situation. A long involved procedure has no place in a tumbling spinning aircraft nearing destruction. He must know what is dangerous and what is not important; does the information sought have a bearing on the tests? Is it in fact possible to get the data? And is the test programme too narrow or too broad or does it simply fail to adequately cover the problem? It is this mixture of piloting skills, engineering knowledge and sound judgment that has proven so successful in the selection of astronauts.



The Manned Orbiting Laboratory, a USAF project, cancelled in 1969, would have been manned by Test Pilot School graduates.

USAF

Acknowledgements

I wish to thank Lt. Colonel Larry Van Pelt (66A), Deputy Commandant, Air Force Test Pilot School, Major Dave Edmondson (75A), Instructor Pilot, S. Sgt. George B. Brooks and Dorthy Goode for their time, help and interest they gave me during my visit to the school on 4 March 1980 and on other occasions.

Note: Larry Van Pelt has been promoted to Full Colonel and is now Chief of the Engineering Branch of the Test Wing, Elgin AFB. Major Dave Edmondson is completing his tour at the school and is being assigned as a student at the Air Force Command and Staff College. Class 79B graduated in June 1980.

SPACE COMMUNICATIONS

L-SAT APPROVED

Final approval has been given for the main development phase of the European Large Telecommunication Satellite (L-Sat) programme. The objectives of the programme are the development, launch, and in-orbit operation of a multipurpose large platform designed for a range of future telecommunications applications on a basis that will maximise future competitivity in the world market.

The four payloads will be for direct broadcasting, specialised/business services, millimetre wave communications and propagation tests.

The decision to proceed with the L-Sat Definition phase was taken in the summer of 1979. A short bridging phase was created to maintain continuity from mid-1981 until the start of the main development phase foreseen at the end of 1981. The total budget for the definition and bridging phases was some 30 Million Accounting Units (MAU) (about $40 million), covering industrial and Agency programme management costs.

British Aerospace was selected as the Prime Contractor for L-Sat in November 1979 and awarded the definition phase contract the following month. Some 40 companies from 12 countries will have responsibilities at subsystem or equipment level.

The details of the main development phase are now practically finalised. The technical definition of the satellite is well advanced and the development plan has been elaborated, leading to a planned launch date in early 1986 by Ariane. Three development test models will be built prior to the fabrication of the flight and flight spare models. Plans are being prepared for the utilisation of the satellite by the user community for experiments, technical tests, demonstrations of new applications, and for revenue-earning services. The budgeted cost of the development phase including the industrial contract, launch, establishment of the ground segment, in-orbit operations for at least five years, and programme management, is 388 MAU at 1980 price levels ($520 million).

THIRD INTELSAT V

Intelsat V-C, the third high-capacity communications satellite of the V series, was launched into space by Atlas Centaur 55 on 15 December. The 4110 lb craft initially headed towards a geostationary position at 15 degrees east longitude (over Intelsat's test station), before being shifted to a new location over the Indian Ocean.

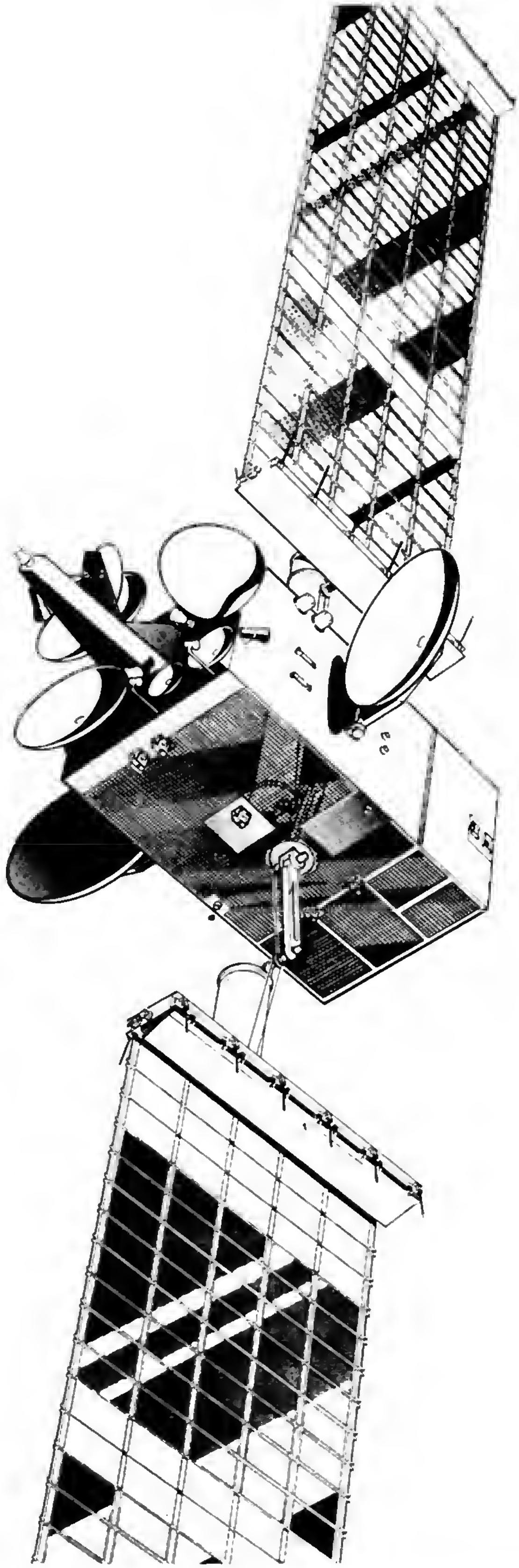
It will go into service there in May, handling up to 12,000 simultaneous telephone calls. The first two satellites of the series were launched on 6 December 1980 and 23 May 1981.

SEA PORT COMMUNICATIONS

Communication via satellite can now be made to and from ships in many of the world's ports. This follows agreement by several countries to allow the use of ship Earth stations within harbour limits and other territorial waters. A number of other countries allow use on a reciprocal basis.

The International Maritime Satellite Organization (Inmarsat) sees this as an encouraging move towards its goal of agreement for all ships anywhere to be able to use their satellite equipment.

The Inmarsat Assembly in November 1981 recommended that all member-States should "take those actions necessary" to make it possible to use ship stations within harbour limits and territorial waters. Such action, it envisaged, could include modification of existing domestic laws and regulations, or other unilateral, bilateral or multilateral measures. The restrictions stem from the time when ships used spark transmitters which



British Aerospace have been given the go-ahead to begin building the first L-Sat communications satellite.

British Aerospace

could interfere severely with local radio stations. Inmarsat ship terminals, on the other hand, do not present such problems.

The use of satellite terminals can be of great use to ships when docking or seeking navigational or other information, in cases of distress or urgency, or when other means of communication are not available.

The first international conference on the establishment of Inmarsat, held in 1975-76, recognised the importance of communications in harbours and adopted a special recommendation stressing the value of ships being able to use satellite equipment within these areas as a means of improving ship management and safety.

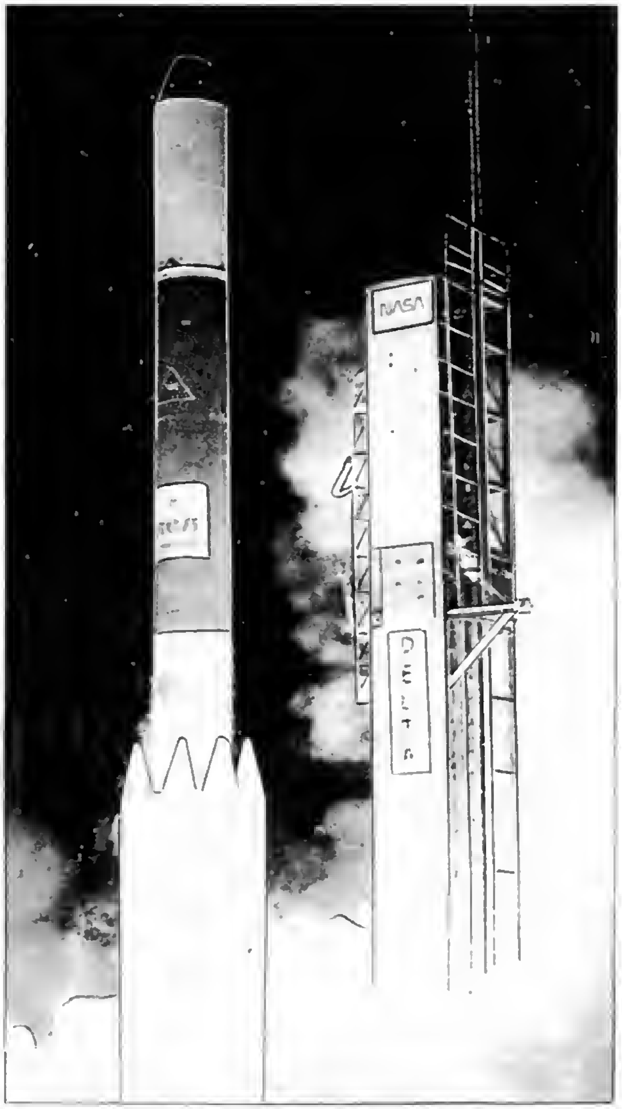
Inmarsat is the 37-nation organisation set up to establish a new global maritime satellite communications system. The system came into operation on 1 February, taking over from that run by the US Marisat Joint Venture since 1976.

ATS 6 EXPERIMENTS

One of the papers presented at the 32nd IAF Congress in Rome last September - "Satellite Augmentation of Cellular Type Mobile Radio Telephone Systems" by Roy Anderson of General Electric - described communications experiments carried out with the ATS-6 satellite and mobile users.

The satellite relayed voice bandwidth communications between five lorries and their dispatchers as they travelled throughout the NE quarter of the United States. The experiment, conducted over a seven month period, demonstrated that propagation characteristics are very different for the satellite-mobile links than for terrestrial-mobile links. A properly designed satellite system can provide high quality, reliable voice and data communications except where the vehicle-satellite path is shadowed by a structure or terrain feature. Mobile equipment in the experiment was adapted from commercial mobile radios. The vehicle antennae were 75 cm tall, 2 cm in diameter.

Another experiment proved the feasibility of vehicle position surveillance using active two-way tone-code ranging through ATS-6 to provide one line of position and passive one-way ranging by measuring the time-of-arrival of a signal from an independent satellite. A position fix was printed out at an Earth station one second after it sent the interrogation signal to the distant vehicle, a towboat on the Mississippi River. The line of position from ATS-6 was accurate to 0.1 nm using a voice bandwidth ranging signal. The line of position from the GOES satellite was accurate to 2 miles, using 100 Hz signal bandwidth.



Launch of the RCA Satcom IV satellite on 20 November (on p. 128 of last month's *Spaceflight* we gave the Florida time date of the 19th) for domestic communication services.

NASA

One of the lorries used in a communications experiment, described in the text above. Note the antenna mounted on the roof of the driver's cab.

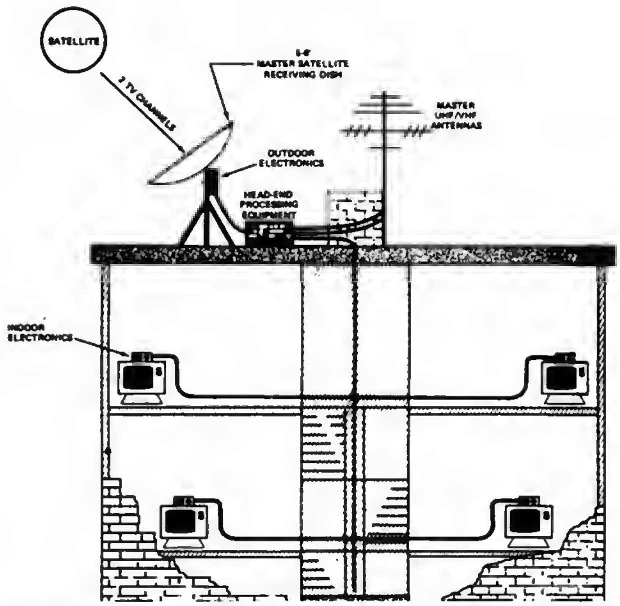
AUSTRALIAN SATELLITES

Australia has selected Hughes Aircraft Company to negotiate for their national satellite communications system, which will carry telephone, television, radio and business traffic.

The system consists of three K band satellites based on the design of Hughes' HS 376 model. They will be launched on either the Shuttle or Ariane booster, beginning in mid-1985. The programme also includes the construction of two tracking, telemetry and command stations in Sydney and Perth.

In announcing the selection, Minister of Communication Ian Sinclair called the move a "major step forward in Australia's development of its own satellite system". Sinclair said the Hughes offering was recommended on technical as well as other grounds and that the Hughes satellite "was the only satellite, in fact, that met our technical requirements completely." Ford-Aerospatiale and British Aerospace-Matra also submitted proposals.

The system will be run by Aussat, a Government-owned company incorporated last November. Aussat will negotiate with Hughes Aircraft International Service Company and report to the Australian Cabinet, which is expected to reach a contractual decision before 1 April 1982.



Typical STC "multiple-dwelling" installation. See news item below.

NEW TV SERVICE

Intelsat has added a new feature to its full-time international television service that should increase the scope and efficiency of television distribution throughout the world. The service, which allows full-time, 24-hour-a-day television transmission over a dedicated network, was established last July. The new feature means that more than one user will be able to send as well as receive transmissions on a full-time basis.

In addition, Intelsat's Signatories will now be able to lease the service, not only on a long-term basis for two years or more, but on a short-term basis as well, for as little as three months, with a possible month-to-month extension up to one year. Before the advent of full-time service, the Intelsat system provided only occasional-use TV service, on a per-minute basis.

Occasional-use service has grown rapidly over the past 16 years, with a total of 572,400 minutes of transmissions during 1980 alone.

Since the initiation of full-time service in July 1981, Intelsat has received indications that up to 10 television channels could be in service by the mid-1980's.

DIRECT BROADCAST SATELLITES

Satellite Television Corporation (STC) – a subsidiary of COMSAT – has urged the American Federal Communications Commission (FCC) to process the various pending direct broadcast satellite (DBS) applications on an individual basis.

On 14 December STC filed with the FCC its comments on seven other DBS applications (STC's own DBS application was submitted a year ago and its comments on the application earlier in 1981).

In its comments, STC urged the Commission to move ahead without delay. The company said that individual processing will serve the public interest "by expeditiously delivering the numerous benefits of DBS to the American people." Individualised processing of each application will "eliminate the possibility that consideration of a few troublesome, potentially flawed proposals would delay the issuance of authorisations to applicants whose DBS systems clearly will serve the public interest."

STC was the American pioneer in proposing DBS services for that country. If the FCC approves DBS applications in early 1982, STC will be able to initiate its DBS pay-TV service in late 1985 or early 1986. STC would offer three channels of programming without advertising, with individual subscribers receiving the scrambled signals using 2½ ft dish antennae.

A listing of planned DBS systems appeared on p.27 of January's *Spaceflight*.

COMMUNICATIONS MEETING

A special United Nations Educational, Scientific and Cultural Organization (UNESCO) study group met with satellite communications experts in Washington, D.C. on 20 November to discuss ways of improving international news distribution.

The study group consisted of news media representatives from the US, Europe and the Third World.

The discussions with executives of Intelsat covered possible improvements in the dissemination of news for the print media, along with international transmission of television and audio programs.

The UNESCO study group was formed by the UNESCO Symposium on regional and international mechanisms for the dissemination and exchange of information, held in Paris in October 1980.

A UNESCO representative said that the group had been encouraged by recent Intelsat moves; in particular, its institution of an Assistance and Development Program and its adoption of a new international television service.

NOTICES OF MEETINGS

Study Course

Theme: **REMOTE SENSING**

The final meeeting of the Study Course takes place in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **10 March 1982**, 7.00–8.30 p.m., with a showing of technical films on the above topic.

Registration forms are available from the Executive Secretary. Please enclose a stamped addressed envelope.

Lecture

Title: **MAN'S JOURNEY INTO SPACE: 1950's STYLE**
by A. B. Perkins and A. D. Farmer

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **11 March 1982**, 7.00-9.00 p.m.
Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

LATE ANNOUNCEMENT

Film Show—Bristol Area

Several films on astronautics will be screened at a meeting arranged for members in the Bristol area. It will be held in the Large Engineering Lecture Theatre, Queen's Building, University of Bristol, University Walk, Clifton, Bristol on **11 March 1982**, 7.15-9.00 p.m.

The programme will be as follows:

(a) The Hard Ones
(b) Spaceship Skylab — Wings of Discovery
(c) STS 1 — Post Flight Conference
(d) Electrical Power Generation in Space
(e) Pollution Below

Members of the Society and their guests are invited. No tickets are required but please apply early for details of future meetings (enclosing s.a.e.) to Mr. F. Barrow, 27 Hazelbury Rd., Knowle, Bristol BS14 9EP.

Film show

Theme: **THE MAKING OF AN ASTRONAUT (PART III)**

Films covering the development of manned space voyages will be screened at a meeting to be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **24 March 1982**, 7.00-8.30 p.m.

The programme will include the following:

(a) Four Rooms, Earth View
(b) Space Shuttle (1977)
(c) Space Shuttle, Overview (1980)
(d) Space Shuttle, Mission to the Future (1981)
(e) STS-1, Post-flight Conference

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Lecture

Title: **MANNED SPACEFLIGHT COMES OF AGE**
by P. S. Clark and A. Kenden

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **31 March 1982**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Lecture

Title: **THE STABILITY OF THE SOLAR SYSTEM**
by Prof. A. E. Roy
University of Glasgow

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **7 April 1982**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Symposium

Theme: **SPACE TRANSPORTATION SYSTEMS FOR THE 1990's**
Organised by P. J. Conchie

Offers of papers are invited for presentation at a one-day meeting to be held in the Society's Conference Room, Society HQ, 27/29 South Lambeth Road, London, SW8 1SZ, on **20 April 1982**.

Registration Forms and copies of the Final Programme will be available from the Executive Secretary in due course. Please enclose a reply-paid envelope with request.

Lecture

Title: **THE TURBULENT SUN**
by Dr. G. M. Simnett
University of Birmingham

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **5 May 1982**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Symposium

Theme: **SPACE COMMUNICATIONS**
Organised by K. C. Pike

Offers of papers are invited for presentation at a one-day meeting to be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **19 May 1982**.

Registration Forms and copies of the Final Programme will be available from the Executive Secretary in due course. Please enclose a reply-paid envelope with request.

Technical Forum

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ on **Friday, 4 June 1982**, 6.30–9.00 p.m., and **Saturday, 5 June 1982**, 10.00 a.m. to 12 noon and 1.30-3.30 p.m.

Topic: **THE SOVIET SPACE PROGRAMME**

It is anticipated that papers will be given at the Friday evening and Saturday afternoon sessions, with some Soviet space films being shown during the Saturday morning session.

Offers of papers are invited. Further information may be obtained from the Executive Secretary of the Society. Members with a special interest in the Soviet space programme are invited to attend. A registration fee of £2.00 is payable. Forms are available from the Executive Secretary on request, enclosing a stamped addressed envelope.

37th Annual General Meeting

The 37th Annual General Meeting of the Society will be held in the Kent Room, Caxton Hall, Caxton Street, London SW1 on Saturday **25 September 1982**, commencing 3.00 p.m.

Details of the Agenda will appear in *Spaceflight* in due course.

Nominations are invited for election to the Council. Forms can be obtained from the Executive Secretary. These should be completed and returned not later than 2 July 1982. Should the number of nominations exceed the number of vacancies, election will be by postal ballot. Voting papers will then be prepared and circulated to all members.

THE RECOVERY OF AMERICAN MANNED SPACECRAFT 1961-1975

By Keith T. Wilson

Introduction

When the Space Shuttle *Columbia* returned to Earth after its maiden flight, the aircraft-like spacecraft made touchdown on a runway at Dryden Flight Research Center in California. This was a major departure from previous American spacecraft landings; all of which have been by parachute at sea. This article is intended to summarise the thirty-one American manned splashdowns which took place in the Atlantic and Pacific Oceans during the period 1961-1975.

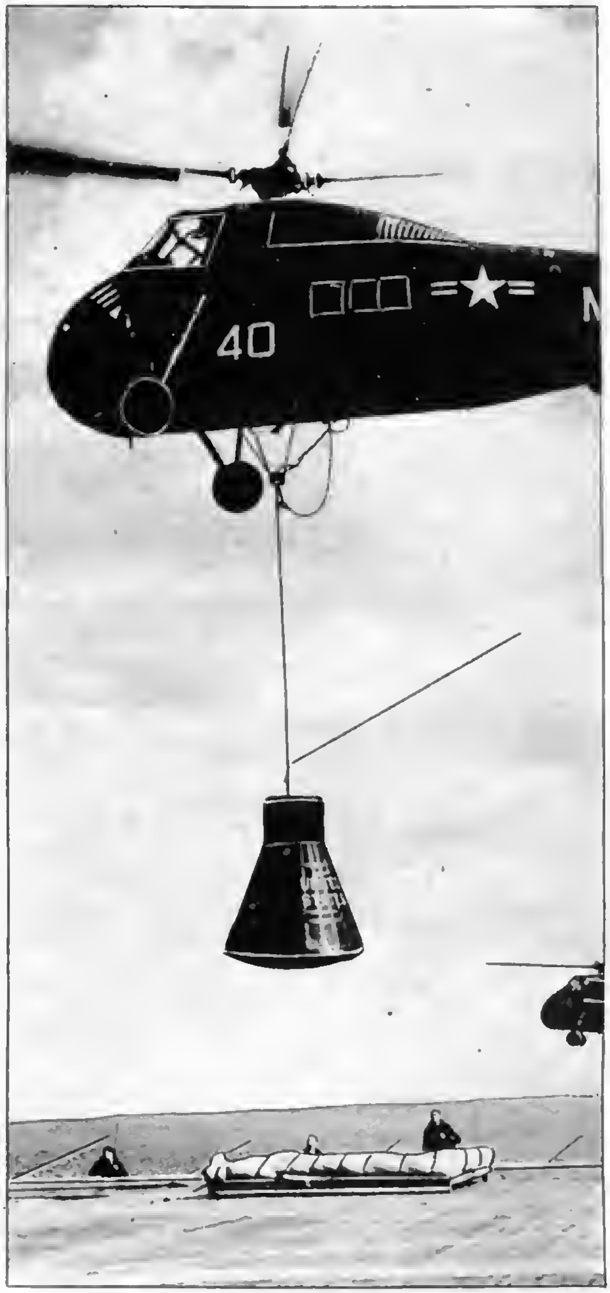
Mercury

It was in late 1958 that a study began on manned spacecraft recovery operations. It had already been decided that water recovery was more favourable than land recovery. Many felt that retrieval operations could prove to be difficult; but with properly designed equipment, helicopter pickup could be used. However, two and a half years were to pass before the first manned splashdown occurred.

On 5 May 1961 astronaut Alan Shepard became the first American to fly in space during the sub-orbital flight of Mercury Redstone 3. Shepard drifted back to Earth under a 19m diameter Northrop ringsail parachute only 486km downrange from the Cape Canaveral launch site. The small capsule hit the water at 10m/sec and the pilot compared this as "a little abrupt, but no more severe than a jolt a pilot gets when he is launched off the catapult of an aircraft carrier". The splashdown, as with all Mercury landings, was cushioned by a rubberised glass-fibre landing bag which was released when the heat shield was lowered. Seconds after hitting the water, the capsule flopped over on its side and it was only when the reserve parachute was jettisoned that the spacecraft began to right itself. Minutes later, one of the recovery helicopters hooked on to the capsule and raised it slightly above the water. Shepard then emerged, entered a sling and was then winched up to the helicopter which transferred the astronaut to the prime recovery ship, the *USS Lake Champlain*.

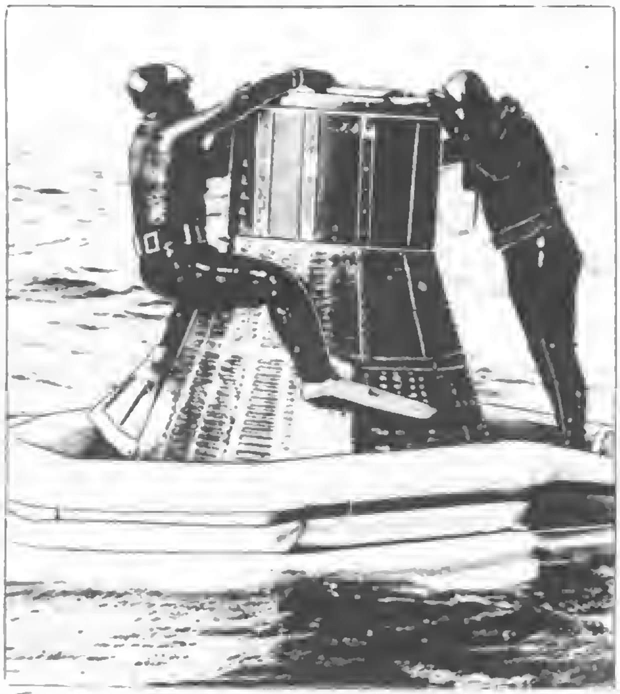
The recovery of the second sub-orbital mission, Mercury Redstone 4, was by no means as successful. The capsule, *Liberty Bell*, "hit the water with a good bump" and a few minutes later while pilot Virgil Grissom was checking over the capsule's instruments the side hatch prematurely blew open, apparently due to a short circuit. Sea water came rushing in over the sill and Grissom, seeing what was happening, lunged out of the hatch into the sea. In the process of doing this the astronaut got entangled in the line which attaches the dye marker package to the spacecraft, but fortunately managed to free himself quickly. The helicopter crew, seeing the sinking spacecraft, hooked onto it to lift it clear of the water, but as this was happening a red warning light appeared in the cockpit to indicate that the helicopter's engine was overheating. This later turned out to be a false signal. The capsule, however, was released and sank to a depth of 4570m. Grissom who had been swimming around for three or four minutes was then picked up, but not before being dragged along in the water for 4.5m by the helicopter before he was lifted up, tired and very wet. Thus, *Liberty Bell* went down in the history books as the only American manned spacecraft to be lost during a mission. Following the loss of Mercury Redstone 4, a number of new procedures came into being to prevent any recurrence of the incident. These included a stipulation that the firing plunger safety pin would be left in place until the helicopter hook was attached to the spacecraft. Grissom had removed the safety pin a short time before the hatch blew open. Also for future missions an inflatable flotation collar would be fixed in place by recovery swimmers.

John Glenn, in Mercury Atlas 6, was next to splashdown in the Atlantic after America's first orbital flight. The accuracy of this landing was not as good as the two previous landings, the capsule landing some 64.5km uprange. *Friendship 7* "hit with a good solid bump" and the capsule went far enough under to submerge both the periscope and window. Glenn reported later that he heard gurgling noises but no leaks were found. For this mission the astronaut remained in the capsule until "Steelhead", the code name for the recovery ship *USS Noa*, came alongside. Twenty-one minutes after splashdown the capsule with Glenn aboard was winched onto the deck where



Recovery of an unmanned Mercury capsule. The spacecraft was small enough to be lifted by a helicopter – later manned vehicles had to be winched up directly on the recovery ships.

NASA



.One of the first tasks of the recovery teams was to attach a flotation collar to the spacecraft.

NASA

the astronaut blew the side hatch of the capsule and emerged none the worse for his three orbits of the Earth. A helicopter later transferred the astronaut to the prime recovery ship, the *USS Randolph*. It is interesting to note that the recovery forces during this mission totalled twenty-four ships and one hundred and twenty-six aircraft.

When Mercury Atlas 7 splashed down on 24 May 1962 it was 402 km from its predicted impact point. The overshoot was traced to a 25 degree yaw error at the time the retrograde rockets were fired. The capsule listed 60 degrees to one side after splashdown and astronaut Carpenter noticed that some water had seeped into the cockpit. Rather than wait in the very hot capsule Carpenter decided to exit the spacecraft *via* the top of the craft and wait in the survival raft for pickup. The astronaut got into the raft before realising that it was upside down! Later, when recovery aircraft reached the area, he signalled with a hand mirror and soon frogmen were in the water attaching a buoyancy collar to the capsule to keep it afloat. The astronaut was then picked up by helicopter and taken to the *USS Intrepid* after being in the water for two hours and fifty nine minutes. The capsule, *Aurora 7*, was picked up by the *USS Pierce* and was found to contain a considerable amount of sea water, the majority of which was believed to have entered through the small pressure bulkhead when the astronaut passed through the recovery compartment to get to the life raft.

The landing and the recovery of the penultimate Mercury mission, Mercury Atlas 8, went according to plan with the spacecraft being recovered in the Pacific for the first time only 7.2 km from the predicted impact point. The splashdown of Mercury Atlas 9, the last mission of the Mercury programme, also went without a hitch. During the recovery the capsule was sighted by the aircraft carrier *USS Kearsarge* and helicopters were deployed to circle the spacecraft during its final descent. After a flawless splashdown swimmers dropped from the helicopters to fix the flotation collar and then a motor whaleboat towed the spacecraft alongside the ship. Cooper did not egress from the spacecraft until it was hoisted aboard the ship, only 37 minutes after splashdown.

Gemini

In early 1961 NASA decided to adopt land landing as a major Gemini objective but the means to that end, the paraglider system, had yet to prove itself. The first active interest in this landing system was in 1959, before the Mercury missions took place. Paraglider was, as the word suggests, a gliding parachute able to guide a returning spacecraft to a preselected site on land. After ejection of the paraglider cannister at 15,000 m the paraglider would automatically take shape as gas inflated the 10 × 11 m structure. The pilot could bank or change his rate of descent and could glide his craft up to 32 km in any direction. Cables attaching the paraglider to Gemini would be severed at touchdown and Gemini would skid to a halt. However, problems occurred with the ejection and inflation of the paraglider from Gemini during tests and in early 1964 after a string of failures the paraglider was dropped. Gemini money was tight at this time and this may have been the immediate reason for the cancellation of the paraglider project.

All ten Gemini missions, like Mercury, landed by parachute in the sea. The heavier capsule however was lowered to a splashdown at 9 m/sec by a 26 m diameter ringsail parachute. Another difference from the Mercury landings was that the Gemini spacecraft lay in the water horizontally rather than vertically.

Gemini 3, the first manned flight of the programme, landed 111.1 km short of the planned impact point due to insufficient lift during re-entry. Shortly before splashdown the two

American Manned Spacecraft Recovery 1961-1976

mission	recovery date	recovery area	recovery ship	landing accuracy [1] (km)
Mercury 3	5.5.61	West Atlantic	Lake Champlain	—
Mercury 4	21.7.61	West Atlantic	Randolph	—
Mercury 6	20.2.62	West Atlantic	Noa [2]	64.5
Mercury 7	24.5.62	West Atlantic	Pierce [2]	402
Mercury 8	3.10.62	Mid Pacific	Kearsarge	7.2
Mercury 9	16.5.63	Mid Pacific	Kearsarge	6.4
Gemini 3	23.3.65	West Atlantic	Intrepid	111.1
Gemini 4	7.6.65	West Atlantic	Wasp	81.4
Gemini 5	29.8.65	West Atlantic	Lake Champlain	168.5
Gemini 6	16.12.65	West Atlantic	Wasp	12.9
Gemini 7	18.12.65	West Atlantic	Wasp	11.8
Gemini 8	17.3.66	West Pacific	Mason [2]	2
Gemini 9	6.6.66	West Atlantic	Wasp	0.7
Gemini 10	21.7.66	West Atlantic	Guadalcanal	6.2
Gemini 11	15.9.66	West Atlantic	Guam	4.9
Gemini 12	15.11.66	West Atlantic	Wasp	4.8
Apollo 7	22.10.68	West Atlantic	Essex	13 [3]
Apollo 8	27.12.68	Mid Pacific	Yorktown	6.5
Apollo 9	13.3.69	West Atlantic	Guadalcanal	4.8
Apollo 10	26.5.69	Mid Pacific	Princeton	5
Apollo 11	24.7.69	Mid Pacific	Hornet	24 [3]
Apollo 12	24.11.69	Mid Pacific	Hornet	6.5 [3]
Apollo 13	17.4.70	South Pacific	Iwo Jima	6.5 [3]
Apollo 14	9.2.71	South Pacific	New Orleans	9
Apollo 15	7.8.71	Mid Pacific	Okinawa	8
Apollo 16	27.4.72	Mid Pacific	Ticonderoga	1.6 [3]
Apollo 17	19.12.72	South Pacific	Ticonderoga	6.4
Skylab 2	22.6.73	Eastern Pacific	Ticonderoga	10.4
Skylab 3	25.9.73	Eastern Pacific	New Orleans	12 [3]
Skylab 4	8.2.74	Eastern Pacific	New Orleans	4.8 [3]
ASTP	24.7.75	Mid Pacific	New Orleans	7.2 [3]

NOTES:

1. Landing accuracy for Mercury and Gemini missions is in km from the predicted impact point. Landing accuracy for Apollo, Skylab and ASTP missions is in km from the prime recovery ship.
2. Secondary recovery ship.
3. Spacecraft landed Stable 2.

astronauts, Grissom and Young, suffered a severe jolt when the spacecraft assumed its landing attitude. After the main parachute deployed, the spacecraft hung from it vertically with its nose suspended at a single point. Just before landing, activation of a cabin switch shifted the spacecraft to a two point suspension with its front end forward and some 35 degrees above horizontal. When Grissom hit the switch the spacecraft dropped into place, pitching both men forward against the capsule, breaking Grissom's faceplate and scratching Young's. The actual landing was mild by comparison but the parachute, still attached, dragged the nose of the spacecraft down in the water. When released, the spacecraft bobbed to the surface. The plan was for the astronauts to stay in the craft until it was picked up by the *USS Intrepid*. Due to the inacurate landing, however, the crew were picked up by helicopter and taken to the recovery ship after a flotation collar was fixed in place by Navy swimmers.

The Gemini 4 crew were also jolted when their spacecraft assumed the two point suspension position, but neither knocked their helmets against anything. The splashdown occurred 81.4 km from the predicted impact point but recovery helicopters were close by to pick up the astronauts. Fifty-seven minutes after splashdown the crew were on the deck of the *USS Wasp*.

Gemini 5 landed 168.5 km short of its predicted landing point due to erroneous information programmed into the on-board computer from the ground. As with the Gemini 3 and 4 crews, this crew was picked up by helicopter. They arrived on the deck of the *USS Lake Champlain* just over one and a half hours after splashdown.

After successfully completing the first space rendezvous, Gemini 6 splashed down 12.9 km from the predicted impact point in full view of live television beamed from the recovery ship *USS Wasp via* satellite transmission. For this mission the astronauts stayed aboard the capsule until it was hauled aboard the recovery vessel. The recovery crew greeted the astronauts with a large banner proclaiming 'Seasons greetings from Wasp'. The *USS Wasp* was in action again only two days later when Gemini 7 landed 11.8 km from the predicted impact point. Thitry two minutes after splashdown the crew were on the deck of the ship after being picked up by helicopter. Schirra and Borman, the commanders of this rendezvous mission had a small bet on who would splashdown closer to the target point. After the Gemini 6 landing, Mission Control told Borman of the computer controlled re-entry procedures used by Schirra and the result of this information was that Gemini 7 landed 1.1 km closer to the predicted impact point than Gemini 6. Borman won his bet!

Gemini 8, with astronauts Armstrong and Scott aboard, had problems in orbit after docking with an Agena target vehicle. This caused the mission to be terminated earlier than planned and resulted in a contingency recovery area being used. Aided by a new on-board computer designed for the Apollo programme the spacecraft splashed down safely into the sea 1110 km south east of Okinawa in the Pacific. Even before it hit the water, the capsule was spotted by an HG-54 Rescuemaster aircraft from Okinawa. Pararescue men parachuted down to the spacecraft and hooked on a flotation collar forty five minutes after landing. The astronauts then exited the spacecraft and awaited rescue in a life raft. After three hours the *USS Mason*, a destroyer, pulled alongside Gemini 8, fastened a line to the spacecraft and the astronauts climbed the Jacob's ladder to be welcomed on deck by the crew. The recovery forces had reacted to this emergency landing as if it had been normal.

Stafford and Cernan aboard Gemini 9 splashed down so close to their recovery ship *USS Wasp* that they were able to open the spacecraft's hatches, relax and even raise their arms and thumb a ride on the *Wasp*. The two astronauts stayed in their spacecraft until it was hoisted onto the ship's deck fifty three minutes after splashdown. The splashdown was the most

Neil Armstrong and David Scott in their Gemini 8 capsule after splashdown.
NASA

accurate of all Gemini flights - only 0.7 km from the predicted impact point.

Both Gemini 10 and 11 splashed down safely. The crew of the *USS Guadalcanal* watched Gemini 10 hit the water and twenty seven minutes later welcomed the astronauts on deck. Gemini 11 also landed close to its prime recovery ship, the *USS Guam*, a sea-going platform for helicopters. The astronauts arrived aboard the ship only twenty four minutes after splashdown. Recovery of the astronauts in both cases was by helicopter.

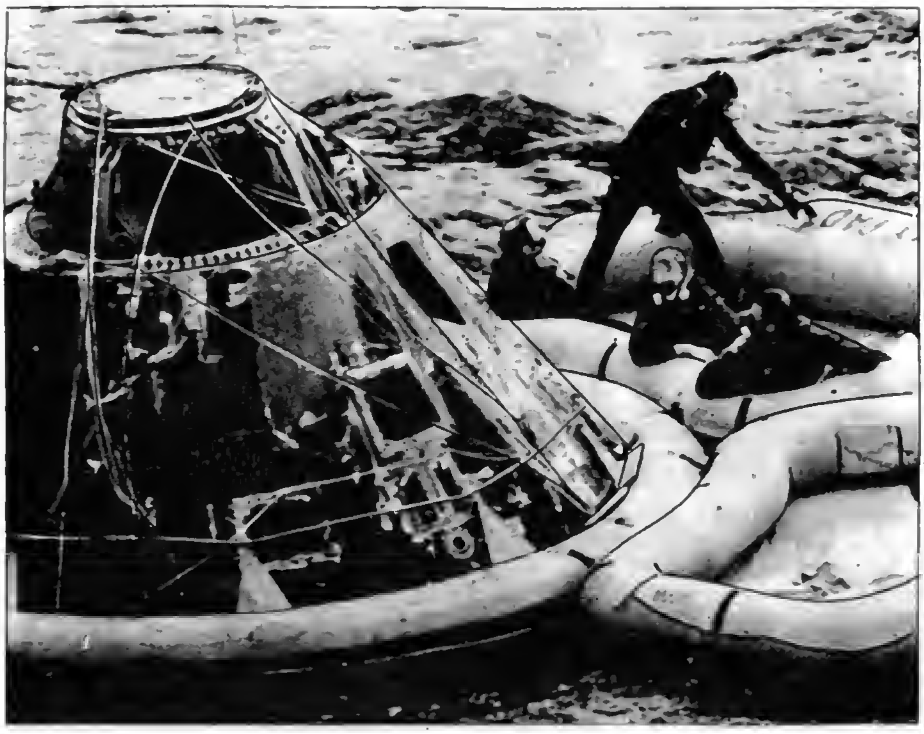
Gemini 12 astronauts Lovell and Aldrin described their landing as 'hard', but the astronauts and capsule were picked up safely and were on the deck of the recovery vessel twenty eight minutes after splashdown. Recovery of this mission was televised live throughout the USA *via* the Early Bird communications satellite.

Apollo

Apollo 7, the first manned mission of the Apollo programme was next to splashdown, nearly two years after Gemini 12. The spacecraft landed in the Stable 2 position (upside down) which was one of the ways the Command Module (CM) could float. Three righting bags in the nose of the CM were inflated to flip the spacecraft over, and seven minutes later the spacecraft became Stable 1. A flotation collar was fixed by Navy frogmen, thus providing insurance against swamping from water taken aboard through the open hatch. The three astronauts were picked up by helicopter and taken to the prime recovery ship the *USS Essex*. Unlike the Mercury and Gemini spacecraft, Apollo landed with three parachutes, each having a diameter of 25.3 m. Landing speed was 8.5 m/sec.

After Man's first trip to the vicinity of the Moon, Apollo 8 landed Stable 2 close to its predicted impact point only 11 seconds earlier than the time given in the Flight Plan. Splashdown came 30 minutes before dawn and the crew decided to remain in the CM until sunrise. A helicopter than trasferred the astronauts to the *USS Yorktown*.

A storm in the selected landing area for Apollo 9 forced Mission Control to move the landing area 800 km to the south.



Recovery of the Apollo 14 crew in February 1971 after the third manned Moon landing. The returning astronauts were no longer required to wear "Biological Isolation Garments" or go into quarantine. Left to right are Ed Mitchell, Stuart Roosa and Alan Shepard.

NASA

However, the spacecraft splashed down only 4.8km from the *USS Guadalcanal*, the prime recovery ship. The only accident during recovery operations was when the down draft from a recovery helicopter overturned one of the life rafts. Apollo 9 was the last American spacecraft to splash down in the Atlantic Ocean. Dawn was just breaking when Apollo 10 floated down to a faultless splashdown 635km east of Pago Pago in the Pacific. The three astronauts were on the recovery carrier only 39 minutes after landing and the spacecraft arrived on board one hour later.

The crew of the first moon landing mission, Apollo 11, landed Stable 2 within 24km of the *USS Hornet* on 24 July 1969. The CM, *Columbia*, righted itself with the aid of the three big flotation bags after eight minutes enabling Navy frogmen to attach the flotation collar. On completion of this task all but one of the frogmen withdrew to a raft 30m upwind of the spacecraft. The remaining swimmer, Lieutenant Clancy Halleberg, opened the CM hatch and passed in three Biological Isolation Garments for the crew. As the astronauts were waiting in the CM, Collins announced "our condition is excellent". One hour after splashdown the crew were winched one by one into a hovering helicopter and after a three minute flight reached the *USS Hornet*. The three astronauts entered the Mobile Quarantine Facility (MQF) and from there were able to speak to President Nixon aboard the recovery ship. This was the first time a returning crew had been greeted in person by a President.

Television viewers saw a 6m high splash when Apollo 12 splashed down in a choppy Pacific Ocean on 24 November 1969. The spacecraft hit hard, landing Stable 2. Once the craft was righted Conrad radioed the recovery forces, reporting "we're in fine shape". Before the landing, television viewers were able to see what appeared to be smoke billowing from the CM. This was actually RCS propellent being vented, an operation usually performed at a higher altitude. Once the flotation collar was attached the crew were transferred to the *USS Hornet* by helicopter. One hour after splashdown the astronauts were in the MQF, above which a sign proclaimed "Three more like before", a reference to the fact that *Hornet* had picked up the Apollo 11 crew.

Of all the American spacecraft landings one of the most publicised was that of Apollo 13, the lunar mission which was terminated early in the flight due to an explosion in the spacecraft's oxygen tanks. British Forces joined in the recovery operations when R.A.F. Command brought its worldwide Shackleton search and rescue reconnaissance aircraft to a state of readiness to help the American authorities. Also, six Royal Navy ships (*Nubian*, *Phoebe*, *Vidal*, *Tideflow*, *Ennerdale* and *Tarbatness*) sailed to the spacecraft's standby splashdown area in the Indian Ocean 259km east of Mauritius. Two Soviet merchant ships (*Akademician Rykachev* and *Novopolotsk*) diverted to the prime splashdown area in the Pacific and Soviet trawlers and whaling ships were ordered to give all possible help in the recovery of Apollo 13. The splashdown came on 17 April 1970 only 6.5km from the recovery carrier the *USS Iwo Jima*, the spacecraft landing Stable 1. Within three minutes a helicopter was overhead and Navy frogmen dropped into the sea to fit the flotation collar. The tension of the four day flight was broken for the astronauts by the first man they spoke to after splashdown, Navy frogman Ernest Jahnche, who opened the spacecraft hatch and told Swigert that an Internal Revenue Service agent was waiting aboard the recovery ship to see him. He was referring to Swigert's failure to file an income tax return before the launch! Forty-six minutes after splashdown the astronauts arrived by helicopter on the deck of the recovery carrier, a scene watched by millions of television viewers worldwide.

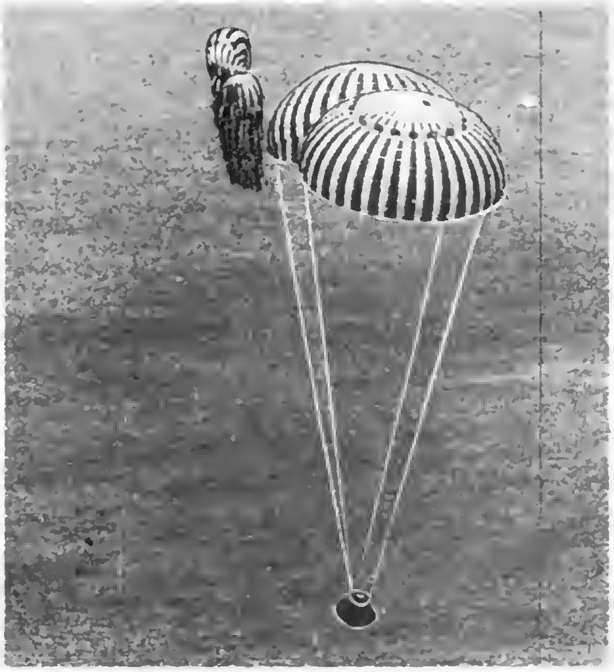
When Apollo 14 splashed down 1448km south of Samoa on 9 February 1971 a line from the main parachute failed to detach and became entangled around the CM as it bobbed in a slight swell. Navy frogmen, however, cut it free and attached a sea anchor and flotation collar. Shepard, the commander, announced that "we're in very good shape in here" and within a few minutes the crew were in a life raft awaiting helicopter pickup.

Apollo 15 landed with only two of its main parachutes at a speed of 9.5m/sec compared to the normal 8.5m/sec with three parachutes. Despite this harder-than-usual splashdown astronaut Scott reported "everyone's in fine shape". The CM submerged briefly and then bobbed up in the Stable 1 position. The astronauts were soon picked up by helicopter and taken to the *USS Okinawa*. NASA narrowed the parachute failure

down to two possible faults. Firstly, and the most likely reason, routine expulsion of RCS fuel by the CM as it came down may have caused contamination of the parachute. Secondly, flaws were detected in steel harness links on the one parachute recovered from Apollo 15. A new metal was used on later missions.

Casper, the Apollo 16 CM landed only 0.5km from its predicted impact point to become the most accurate splashdown of the American manned spaceflight programme. The CM landed Stable 2, the fifth Apollo to do so, a position it remained in for four minutes. This was partly due to the fact that it was dragged by its three main parachutes after it hit the water. The three large flotation bags were inflated and this changed the buoyancy characteristics and righted the bobbing craft. The commander, John Young, radioed "we finally got this thing right side up and we're doing fine. The condition of the astronauts is outstanding, it's super". After splashdown, ten frogmen were in the water when usually only three or four are involved in this procedure. The reason — to retrieve the three main parachutes to allow scientists to inspect them for any clue to the Apollo 15 parachute failure. Forty-five minutes after splashdown the astronauts were on the recovery carrier. RCS fuel was retained on Apollo 16 to insure against a repeat of the Apollo 15 parachute failure. The wisdom of jettisoning this fuel became apparent when during the draining of the propellents at the Rockwell International plant at Downie California, an explosion occurred causing damage and injuring a number of technicians.

The splashdown and recovery of Apollo 17, the final Apollo mission was flawless. The CM splashed down gently into calm seas only 6.4km from the recovery carrier, the *USS Ticonderoga*. The accuracy of the splashdown enabled one of the recovery helicopters to position itself directly over the descending spacecraft during the last few metres before impact. The three astronauts were aboard the *Ticonderoga* 53 minutes after splashdown.



A failed parachute provided a dramatic end to the otherwise successful Apollo 15 lunar mission.

NASA

Skylab

When Skylab 2 returned to Earth after a 28 day stay in space, the three astronauts remained inside the CM until it was hoisted aboard the recovery carrier, the *USS Ticonderoga*. This was the first time this had happened since Gemini 9 in June 1966 and the reason for this procedure was to protect samples and experimental data onboard the CM from the warm moist sea air. Also, many doctors felt that after a long period of weightlessness the crew might not have been able to exit the CM safely for a helicopter pickup. Swimmers dropped from a helicopter with flotation gear as in the past but then the aircraft carrier itself manoeuvred up close to the capsule and hoisted it aboard. When the astronauts emerged from the spacecraft 40 minutes after splashdown onto the deck of the recovery ship they appeared unsteady but well.

Skylab 3 landed in the roughest sea encountered by returning astronauts. The spacecraft landed Stable 2 and even

Relief shows on the faces of the three Apollo 10 astronauts (left to right: Cernan, Young and Stafford) aboard the *USS Princeton* in May 1969. Their successful mission paved the way to the first manned lunar landing that July.

NASA

when the three flotation bags righted the spacecraft it nearly tipped over as Navy frogmen tried to secure the flotation collar. Despite the 2.4m high waves the flotation collar was fixed in position and the CM was then winched aboard the *USS New Orleans*, only 40 minutes after splashdown. Three minutes later the astronauts emerged from the CM, slightly unsteady, and were assisted by doctors as they were taken off for medical examinations.

The final Skylab mission, Skylab 4, also landed Stable 2, within 5km of the *USS New Orleans*. Minutes before splashdown the crew had been warned to wear oxygen masks because of fears of toxic fumes seeping into the capsule from a thruster jet which began leaking as they started their return to Earth. The CM remained Stable 2 for five minutes as the flotation bags were inflated to right the craft. Within an hour the spacecraft was on the deck of the recovery carrier and as with Skylab 3, the astronauts had to be helped across the deck. This was the first splashdown since 1966 that had not been covered on live television. The television networks decided against live coverage because of public apathy!

ASTP

The landing of the last American Apollo spacecraft, the Apollo used during the joint Soviet-American mission, nearly ended in disaster. Following reentry, the Earth Landing System (ELS) was not activated. One of the ELS functions was to cut off the roll thrusters, used to provide roll stabilisation of the spacecraft during reentry, and so the RCS system was kept operating for a longer period than normal, causing the CM to oscillate during parachute descent. Stafford, the commander, noticed the thrusters firing and so cut off the propellent flow. However, nitrogen tetroxide fumes continued to enter the cabin through the pressure relief assembly which equalised the pressures inside and outside of the spacecraft. As the ELS had not been activated the main parachutes had to be deployed manually, this being the first time that had happened. During the last four minutes of descent the three astronauts were hardly able to breathe due to the fumes and, because of a great deal of aerodynamic noise and communictions interference, Mission Control and the recovery forces were unaware of what was happening. The CM "hit the water like a ton of bricks" (Stafford later said that the splashdown reminded him of Gemini 9) and capsized when some of the parachute shrouds caught on the CM's nose. As the spacecraft was Stable 2 Stafford struggled to get at the oxygen masks located behind the astronauts couches. Brand, meanwhile, had passed out and had to be revived with oxygen. Once the CM righted itself Stafford radioed "We're okay now. We are in Stable 1 position". He then opened the hatch slightly to let some fresh air in before Navy frogmen reached the craft. A flotation collar was soon in place and recovery was in Skylab fashion with the CM being winched aboard the *USS New Orleans* only 45 minutes atter splashdown. All three astronauts had been affected by the nitrogen tetroxide fumes and were hospitalised for two weeks in Honolulu.

And so, after thirty-one manned splashdowns, the recovery of American spacecraft and astronauts at sea ended.

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SATELLITE DIGEST – 153

Robert D. Christy

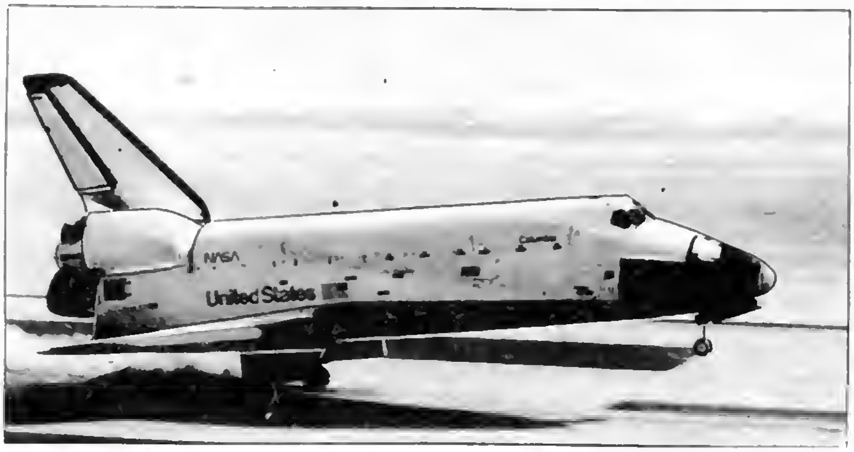
Continued from the March issue

A monthly listing of satellite and spacecraft launches, compiled from open sources.

The heading to each launch gives the name of the satellite or craft, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes, except where marked with an asterisk, where the time is to the precise minute as announced by the launching agency.

COSMOS 1318 1981-109A, 12936

Launched: 1259, 3 Nov 1981 from Plesetsk by A-2.
Spacecraft data: Possibly based on Vostok manned spacecraft with spherical re-entry module, instrument unit and a cylindrical supplementary payload at the forward end. Length about 6 m, max diameter about 2.4 m, mass around 6000 kg.
Mission: Military photo-reconnaissance, recovered after 30 days.
Orbit: Initially 171 × 352 km, 89.75 min, 67.14 degrees, then manoeuvred several times to provide coverage of particular target areas.



Touchdown of Orbiter *Columbia* after its second space trip.

NASA

VENERA 14 1981-110A, 12938

Launched: 0530, 4 Nov 1981 from Tyuratam by D-1-E.
Spacecraft data: Cylinder with two solar panels and an experiments package located at one end. Length (excluding experiments) about 2.7 m, diameter about 2.3 m maximum, mass around 5000 kg.
Mission: Continuation of the Soviet Union's Venus exploration programme. The craft is due to arrive near Venus in March 1982 and may carry a surface lander. Soviet reports indicate that this vehicle and its predecessor (see last month's table) are very similar in design and purpose. During the flight to Venus, observations are being made of x-rays and gamma radiation, as well as measurements of magnetic fields, the solar wind and interplanetary plasma. In addition to Soviet-built equipment, both craft are equipped with French and Austrian-designed scientific apparatus.
Orbit: Heliocentric, but initially a low parking orbit around the Earth at 51.6 degrees inclination. A trajectory correction on Nov 14 ensured an arrival in the vicinity of Venus on 5 March 1982. A similar manoeuvre by VENERA 13 on 10 Nov kept that craft on course for a Venus arrival on 1 March 1982.

An image of the aurora oval at the Earth's north pole taken by one of the Dynamic Explorers (see "Satellite Digest-150", *Spaceflight*, January 1982) last September.

NASA

STS 2 1981-111A, 12953

Launched: 1510*, 12 Nov 1981 from the Kennedy Space Center.
Spacecraft data: Re-usable shuttle craft *Columbia* with fixed experimental packages in the payload bay.
Mission: The second flight in *Columbia's* orbital test programme, crewed by spacecraft commander, Colonel Joe H. Engle of the USAF, and pilot Commander Richard H. Truly of the USN. As well as systems testing, other major operations were the testing of the remote manipulator arm to be used for unloading and retrieving spacecraft, and evaluation of the craft's ability to serve as a steady platform for Earth Viewing Instruments.

Most of the Earth observation equipment was mounted on a Spacelab-type pallet built by British Aerospace for the European Space Agency. OSTA-1 (named after NASA's Office of Space and Terrestrial Applications) weighed 2542 kg and was mounted near the centre of the equipment bay, and consisted of five experiments; two further experiments were carried in the crew compartment. The external equipment was:

Shuttle Imaging Radar – A: physically the largest part of the payload, consisting of a Seasat-type microwave radar providing map-like images of the Earth's surface. During the

flight, images were obtained over North and South America, Africa, Europe and Asia. All objectives of the experiment were met during the flight.

Shuttle Multispectral Infrared Radiometer: a complementary instrument to the radar intended to determine the best spectral bands to use in remote sensing of rock types. 108 minutes of observation were obtained in ten bands of the spectrum between 0.5 and 2.5 micrometers wavelength.

Feature Identification and Location Experiment: intended to help development of equipment which can be used to identify particular types of surface feature. Such equipment could be used to switch remote sensing instruments on and off automatically. About 32 hours of data were obtained.

Measurement of Air Pollution from Satellites: consisted of a carbon monoxide detector studying the middle and upper troposphere. About 32 hours of data were recorded, some of it being checked independently by airborne monitors over Virginia, Florida and California.

Ocean Colour Experiment: returned 78 minutes of data on chlorophyll concentrations under its programme to test the ability of an automatic sensor to locate plankton, and consequently to guide fishing fleets to fish feeding areas or away from areas of pollution.

Night/Day Optical Survey of Lightning: carried in the crew compartment; was a hand-held instrument intended for recording lightning flashes. Little, if any, usable data was collected.

Heflex Bioengineering Test: a sealed unit containing Helianthus Annus (dwarf sunflower) plants was a preliminary test of a planned Spacelab experiment. Owing to the shortened flight (it had originally been planned as five days), the experiment was not completed.

Orbit: Columbia carried out a number of manoeuvres using the Orbital Manoeuvring System (OMS), the highest orbit reached was 255 × 265 km, 89.57 min, 38.03 degrees. The mission was shortened due to a problem with one of the three onboard fuel cells providing electrical power. Columbia landed at 2123, 14 Nov 1981 after a flight of 2 days, 6 hours, 13 minutes.

COSMOS 1319 1981-112A, 12954

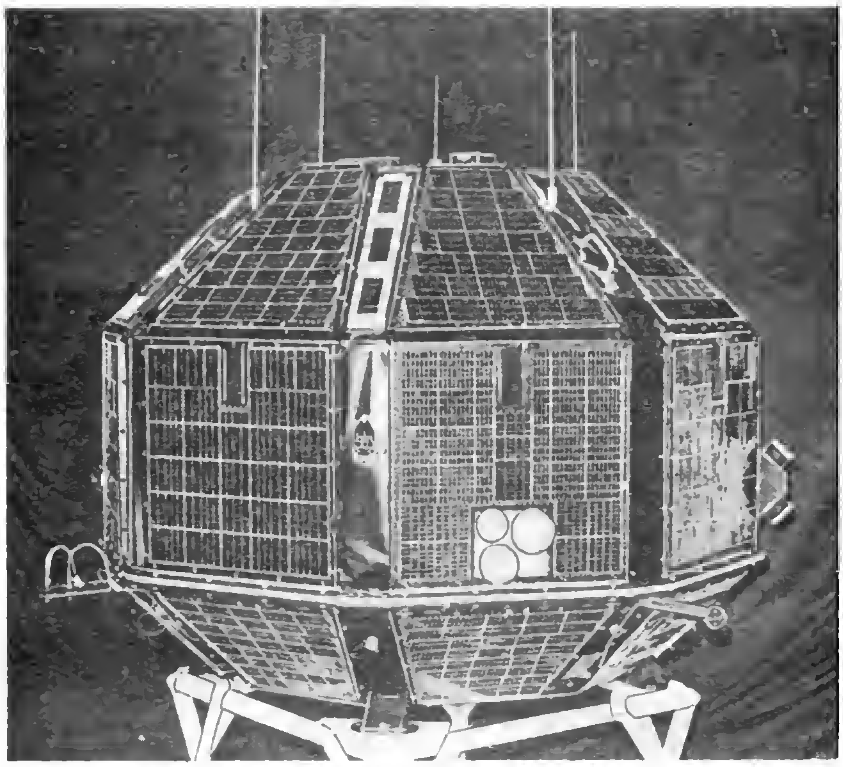
Launched: 0930, 13 Nov 1981 from Tyuratam by A-2.
Spacecraft data: As Cosmos 1318.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: Initially 207 × 337 km, 90.37 mins, 70.35 degrees. Manoeuvred to 349 × 415 km, 92.21 min, 70.37 deg, an orbit which provided area coverage of the whole Earth by the end of the flight.

MOLNIYA-1 (51) 1981-113A, 12959

Launched: 1525, 17 Nov 1981 from Plesetsk by A-2-e.
Spacecraft data: Cylindrical body housing instrumentation and the payload, surmounted by a conical motor section. Power is provided by a "windmill" of six solar panels. Overall length 3.4 m, diameter 1.6 m, mass around 1800 kg.
Mission: Replacement for Molniya-1(39). The satellite helps to operate long distance telephone and telegraphic communications and broadcasts central television programmes via the Orbita system to remote areas of the Soviet Union.
Orbit: Initially a low parking orbit and then injected into a highly elliptical one of 444 × 39133 km, 702.06 min, 62.78 deg. Later manoeuvred to 469 × 39924 km, 718.53 min, 62.82 deg to provide daily repetition of the ground track.

RCA SATCOM 3R 1918-114A, 12967

Launched: 0130*, 20 Nov 1981 from Launch Complex 17A, Eastern Space and Missile Centre, Cape Canaveral Air Force Station by Delta 3910.
Spacecraft data: A box-shaped body 1.62 × 1.25 × 1.25 m carries spacecraft housekeeping equipment and a communications relay package. Power is provided by two extended, flat solar panels of 8.4 square metres giving 1 kW of power for battery charging. The mass in geostationary orbit is 550 kg.
Mission: To provide distribution of programmes to cable television systems in the United States.
Orbit: Placed into geostationary transfer orbit by the launch vehicle and injected into geostationary drift orbit by the satellite's integral apogee boost motor. Stabilised at the operational location of 132 degrees west longitude.



Bhaskara 2 (1981-115A), similar in appearance to its predecessor (1979-51A), is an Earth-observation satellite.
ISRO

BHASKARA 2 1981-115A, 12968

Launched: 0825, 20 Nov 1981 from Kapustin Yar by C-1.
Spacecraft data: 26 faced, quasispherical polyhedron, 1.55 m high, 1.66 m diameter and mass 436 kg. Power is provided by Nickel-Cadmium storage batteries of 10 amp hours capacity and fed by a body mounted solar array of 47 watts output. Attitude sensors include an infra-red horizon sensor, a Sun sensor, tri-axial magnetometers and temperature sensors. Attitude control is by a cold gas reaction jet system and the satellite is also fitted with a magnetic nutation damper. It was designed and built by the Indian Space Research Organisation.
Mission: Mainly Earth observation using a pair of TV cameras operating in the 0.54–0.66 and 0.75–0.85 micrometre bands respectively, and three microwave radiometers working at 19.35, 22.235 and 31.4 GHz. Other experiments include solar cell experiments and a study of thermal control coatings.
Orbit: 521 × 543 km, 95.20 min, 50.64 deg.

COSMOS 1320-1327 1981-116A-H, 12975-12982

Launched: 1807, 28 Nov 1981 from Plesetsk by C-1.
Spacecraft data: Possibly spheroidal in shape, mass about 40 kg each.
Mission: To provide tactical communications between troops or units in the field. The previous launch in the series was 1981-74.
Orbits: Lowest: 1481 × 1605 km, 116.98 min, 73.98 deg; highest: 1481 × 1633 km, 117.29 min, 73.98 deg.

SOCIETY MEETINGS

EXPLORING VENUS

Our understanding of the planet Venus owes a great deal to the Pioneer-Venus spacecraft which went into orbit about that body in December 1978. Indeed, data from the radar instruments were used by the Soviets in establishing landing sites for their own latest probes, Veneras 13 & 14, launched towards the end of last year and due to arrive this spring.

Venus is a fascinating planet and the Society was fortunate in having Dr. Fredric Taylor, Principal Investigator for the infrared radiometer abroad the Pioneer orbiter, to describe the latest findings in a lecture on 18th November last.

Dr. Taylor's experiment, which ended in February 1979 because of power problems, studied the structure and variability of the "middle" atmosphere of Venus (60 to 140 km) by using an infrared remote sensing instrument developed from those carried by terrestial weather satellites.

Most of the equipment was built at JPL, but one of its detectors (the pressure modulator radiometer) came from Oxford, making it the only piece of British equipment to fly to the planets so far. The experiment provided temperature readings for the atmosphere above the cloud tops, with the measurements covering most of the planet (major exceptions were the south polar region and much of the southern hemisphere because of the way the instrument was positioned). The readings also covered a large vertical range: from the cloud tops at 65 km (the clouds themselves being opaque to infrared) up to 140 km (the lowest point in the spacecraft's orbit). This resulted in a million vertical temperature profiles during the three months of operation!

Dr. Taylor highlighted three especially puzzling features, still not fully accounted for:

1. A "hot spot" was expected where warm air carried up from the equator in the upper atmosphere falls over the pole (the warm air falling over the polar region, then flowing back to the equator at a lower level, to complete a classic Hadley Cell circulation pattern.) However, at Venus' north pole there is no simple warm spot, but a dipole - a double hot spot phenomenon circulating about itself. The dipole shows up as two clearings in the cloud, the polar clouds being driven by the strong down-flow to lower, hotter levels where they evaporate and may disappear entirely.
2. The readings also show up a cool polar collar - a constant current of cold air going round the pole at 70-80° latitude.
3. The third mystery is a tidal pattern of warm points above the equator. On Earth the sub-solar point (the spot immediately below the Sun) is the warmest point on the equator, with the temperature of the atmosphere declining fairly evenly in either direction around the equator. This means that the night-time point directly opposite the sub-solar point is coldest of all. However, on Venus, the temperature declines on either side of the sub-solar point but rises again to form another warm "peak" at the point furthest from the sub-solar point. Some form of tidal mechanism must be at work.

The relatively recent fly-bys of Saturn have tended to eclipse the exploration of Venus but, clearly, there are still a great many mysteries waiting to be solved.

VISIT TO PLANETARY LABORATORY

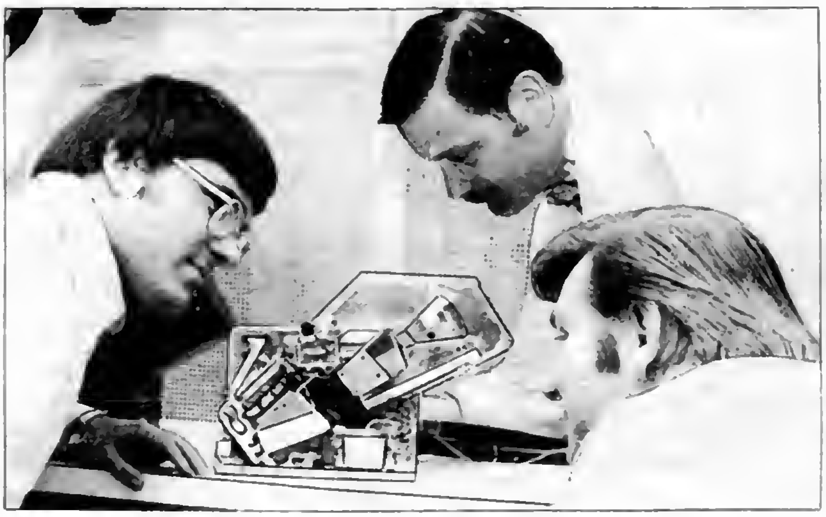
Members taking part in the Society's "Remote Sensing" course were fortunate to visit the Laboratory for Planetary Atmospheres at University College London on the evening of 9 December 1981.

Dr. Garry Hunt, head of the laboratory, described the unique facilities which have been developed to aid planetary research using data from Voyager, Meteosat, Tiros, Landsat, Seasat and HCMM. IPIPS (Interactive Planetary Image Processing System) consists of a VAX 11/780 computer, two tape drives, 320 Mbytes of disc store and two special display devices - the PPL 121 video display and the I^{2}S System 70E digital display. The system supports six work stations. These facilities represent the most advanced image processing equipment available in Europe for meteorological investigations.

The key aspect is the interactive nature of the facility which provides a rapid response to the operator's commands when working on an individual display. A special characteristic is the development of time lapse sequences which display the motions in planetary atmospheres, and therefore serve as a direct indication of the dominant weather systems.

A 4 m antenna stands on the roof of the LPA building to receive digital images directly from Meteosat for processing using IPIPS.

Time lapse sequences of images from the satellite (produced every 30 minutes) showed that, at the time of the visit, Spain was suffering from low rainfall and Britain was being battered by cold, snowy weather.



Left: Dr. Frederic Taylor (at the right of the picture) and engineers with the flight model of the Pioneer-Venus radiometer. *Below:* Dr. Gary Hunt with his BIS visitors at the Laboratory for Planetary Atmospherees.

THE 36TH ANNUAL GENERAL MEETING

A REPORT OF THE DISCUSSIONS

In the Chair: Mr. A. T. Lawton *Vice-President*

In attendance: *Members of the Council*

Mr. P. J. Conchie	Dr. L. R. Shepherd
Prof. C. V. Croves	Mr. C. J. N. Smith
Dr. W. F. Hilton	Mr. C. R. Turner
Dr. W. R. Maxwell	Mr. C. M. Webb

And about 60 members

Presidential Address

Mr. A. T. Lawton welcomed all present on behalf of the President, who had been unavoidably detained by other business. He began by outlining some of the highlights in the Report of the Council for the year ended 31st December 1980.

In basis, the Society passed through 1980 - with all its economic trials and difficulties - successfully. Many of those present would have heard reports of difficulty from other Societies and have read in the press of adverse conditions generally. In our own case, we had not only survived these conditions but had began the work of laying the foundations for expanding activities.

In 1980, our programme ran at a level about 30 per cent higher than the previous year. It also included the task of acting as host-Society for the 17th European Space Symposium, in which our co-partners and ourselves had been joined by the American Astronautical Society for the first time, so providing an opportunity to extend and cement long-standing bonds of friendship. Besides this, we also continued with the further organisation of our Headquarters.

We also continued the production of our magazines, although in a very tough year. As someone personally involved, Mr. Lawton said he was not exaggerating on that point. The problems had been coped with only by very careful management. Not only had we adopted a truly professional approach, but were seen to do so in the eyes of others.

In times when others were going down, we even produced a new book, *High Road to the Moon* - a blend of what our forebears thought might happen and what actually *did* happen. Most interesting of all, it provided an accurate gauge of the Society's ability for forecasting events!

The Library, another highlight of 1980, was one of the activities on which we shall concentrate in future. Our aim is nothing less than making it one of the best UK reference sources for astronautics, space activities and related subjects.

He concluded by saying that the Society can now set new goals but, before doing so, tribute should be paid to the staff for their devotion and hard work, not just in keeping the Society alive but also making it grow. If Members had the slightest inkling of the prodigious effort involved, they would know that these thanks were well-deserved.

Shortly the Society will reach its 50th year. The event would be heralded by our special meeting, *Space '82*, which would be held next November. Every Member, both at home and abroad, will be invited to join our celebrations. It was very gratifying that the Society has survived that long, on its own feet, when so many others have either collapsed or lost their identities on the way.

It was then moved by Mrs. Y. L. Cooper (Associate Fellow), seconded by Mr. P. Cirton (Fellow), that the Report be accepted. This was carried unanimously.

Balance Sheet and Accounts

The Executive Secretary then reported on the Balance Sheet and Accounts for the year to 31st December 1980. He said that, after a long period when one year's accounts really looked more or less like another, we now had an opportunity to watch a transition, for the accounts before the meeting really presented a snapshot of a transformation.

They needed to be looked at in two ways:

(a) On the Income and Expenditure Account, the main factor was that this was approximately in balance. Income had gone up, but so had expenses, particularly the cost of our magazines, though this higher figure was not strictly comparable with that for the previous year because even this enhanced figure had been insufficient to pay for the same number of magazines as had been issued in 1979.

At one time, the deficit for the year had looked as though it might run to £20-25,000, hence the Council's intense concern with financial management throughout the year.

The result, however, had proved that the Society could successfully navigate these difficult waters. We had successfully avoided the twin perils of borrowing money at high interest rates or becoming insolvent.

(b) The second way of looking at the Accounts was to examine the Balance Sheet. When we began the year, the Society was faced with indebtedness on its HQ premises exceeding £27,000. By the end of the year donations from members and a variety of fund-raising activities had brought in the astonishing total of nearly £19,000, thus reducing the debt to manageable proportions by the end of the year.

Of these extra funds, over £1,500 had come from the completion of Deeds of Covenant, hence the wish of the Council to persuade as many members as possible liable to UK tax to help the Society, at no cost to themselves, by completing a Deed. The Tax Laws as now detailed are much more lenient to would-be Covenanters. Donations from Members exceeded £9,000. The balance was made up by profits from miscellaneous fund-raising activities.

On the proposal of Miss P. Wright (Fellow), seconded by Dr. W. F. Hilton (Fellow), the Balance Sheet and Accounts for the year ended 31st December 1980 were approved unanimously.

Appointment of Auditors

The Chairman pointed out that our auditors, Fraser Threlford and Co., had merged with Norton Keen & Co. during the year, the combined firm continuing the practice under the name of Fraser Keen. They now offered themselves for re-election.

On the proposal of Mr. T. J. Grant (Fellow), seconded by Mr. P. S. Clark (Fellow), the re-election of auditors at a remuneration to be agreed upon by the Council was approved unanimously.

Council Elections

The Chairman then stated that, in accordance with the Society's Articles, four Members of the Council were due to retire. Of these, three (C. V. Croves, W. F. Hilton and C. V. E. Thompson) had offered themselves for re-election. Dr. W. R. Maxwell was not standing for re-election this year. His colleagues on the Council were very sorry to lose him and would like to thank him sincerely for all the work he had done in supporting the Society during some of its most critical years. It was hoped that we would not lose sight of him entirely and that he would be able to attend the various activities planned during the forthcoming years.

Six other nominations had been received, so there was a total of nine candidates.

Election would be carried out by postal ballot in the usual

manner, with 31st January 1982 adopted as the final date for the return of ballot papers, as was our normal practice.

This was approved.

General Discussion

Mr. F. R. Smith (Fellow) referred to IAF Congresses which, he understood, were to be held every two years infuture instead of annually. He asked that the Council, before making up its mind on whether to support this proposal or not, consult with interested members first of all.

Dr. L. R. Shepherd (Chairman of the International Liaison Committee) replied that not only did this matter lie solely in the hands of the member-Societies of the IAF, and not simply of this Society, but that no decision could possibly be made by anyone without hearing both sides of each of the arguments for two alternative courses of action. The position was that the IAF Bureau had undertaken to prepare a document detailing the *pros* and *cons* of each case which they would send to the member-Societies in order that they could reach a firm decision next year. The BIS was now awaiting such a document.

In considering this there would be a great many factors to be taken into account, all of which underlined the need for the IAF, as a whole, to determine what decision would be best suited to its interests.

The Executive Secretary added that the initial proposals had included a statement that, in the years when no Congress was held, a number of specialised meetings would be arranged, together with opportunity provided for IAF partici-ation in COSPAR meetings, which would be held every two years to alternate with the IAF Congresses.

In regard to consultation with individual members, this really involved a question of principle which might be extended to any conceivable subject. Members had entrusted the management of the Society to their Council and the Constitution clearly specified that the Council should accept and carry out this task.

To endeavour, by any means, to require the Council to be guided by individuals professing some particular interest would prevent it from discharging the responsibilities for which it had specifically been elected. This was clearly out of order and unconstitutional.

Dr. L. R. Shepherd added that our delegates at Congresses are often confronted with a wide range of new issues. We couldn't possibly refer each one to Society members! In coming to our conclusions, it would be more important to take note of what our fellow-Societies were thinking.

Dr. Hilton commented that three hours of discussion had taken place at the IAF session on this subject before a decision to defer had been reached. The Chairman added that he hoped this meeting wouldn't follow suit!

Mr. T. J. Grant (Fellow) asked why *JBIS* was not included in the British Technology Index. The Executive Secretary said that he was not aware that listings for *JBIS* had been discontinued and undertook to look into this.

Miss P. Wright (Fellow) asked how the Society's Education Programme was progressing in view of the issue of *Space Education*, published initially as a supplement to *Spaceflight* and, in her opinion, a very good magazine.

Professor Groves replied that the first issue of *Space Education* had been very well received. As far as could be ascertained, it was the first in its field and probably represented another original breakthrough by the Society. However, the main requirements for any magazine was it had to be financially viable if it was to be established on a permanent basis. For this reason, it had been proposed that *Space Education* be placed on a separate subscription for next year, though a second issue was now in preparation for the end of the year without any further financial commitment from members. *Space Education* would be maintained at two copies a year for 1982 though, if sufficient support were forthcoming, both in subscriptions and material for publication, it might become a quarterly magazine later on. This was an outstanding example of the vigorous "push" the Council were determined to give to the Society. We were not out to say but also to show what we are doing.

We are building a very strong point of contact around this publication with teachers and younger people. For example, there was little or nothing available in the way of a prospectus to those who wished to take up astronautical engineering, a matter we had once rectified.

The Chairman made the point that in order to comprehensively educate and acquaint people in the UK as to what was happening in terms of the economic impact of developments in space engineering, the Society must also "inform" members of the Government. It should also attempt to penetrate the média because until it could make clear to key people just how much the UK was missing out both in financial and technological terms, there was no point simply in highlighting ideas on astronautics.

Mr. A. Bond (Fellow) strongly reinforced this point and expressed his concern about some recent TV programmes. The BBC "Horizon" series had included an extraordinarily good programme on the exploration of Saturn by Voyager. Commentaries had been good and the visual material excellent. Unfortunately, there had also been another Horizon programme devoted to CETI (Communication with Extra Terrestrial Intelligence), and this programme could only be described as abysmal. He felt very sad that the BIS had not been involved in a similar venture for we could present a much better appeal to the British public. He felt that we should make every effort to contact appropriate people, if it were known that such programmes were in future contemplation.

Mr. Mat Irvine (Member) pointed out that he *had* contacted the person involved in the Horizon programme and received the answer he expected namely "Money". Shortage of money is always the problem. However, he felt sure that there would be future opportunities but had to point out that programmes cannot be entirely UK in outlook. It is necessary for them to have an international outlook, particularly with American audiences in mind. It is a fact of life that entertainment and enjoyment come first, with education very much a secondary consideration.

Mr. C. Webb (Fellow) said it was important to get things done the right way. It was particularly necessary to get the Society's name across, for publicity about our work not only would help the Society but enhance Space activities.

The Chairman supported these comments very strongly and agreed that a firm endeavour should be made to move in this direction, in spite of undoubted difficulties to overcome on the way. He felt that, with rare exceptions, the general media did not spare the time and trouble to find out, still less spell out the affiliations of some of its interviewees!

It was often up to the interviewee to state clearly the name and nature of the group to which he belonged. If the interviewer got it wrong then it took a very strong-willed person to put it right, especially if the interview was live and time precious.

The Executive Secretary, commenting on the need to get the Society's name across, mentioned, ruefully, that he had once been introduced, in an otherwise excellent programme as "the Secretary of the British Inter-Ballistic Missile Society!"

Miss P. Wright (Fellow) suggested that the BBC programme, "Open Door", was concerned with the making of semi-documentaries and also allowed such points of view to be made available to the public.

Several other members spoke in support of Mr. Bond's remarks, including Mr. J. Sved (Associate Fellow) who explained that he had just arrived from "down under" (Australia to be exact) and illustrated how the same problem had been tackled in that part of the world. Basically, the approach had been to secure a good collection of visual aids and other material, which made it necessary for the TV Authorities to make approaches for the use of this material and hence allow a "say" in how it could be used. It had been recognised that

different programmes had different forms of emphasis and presentation. Another important matter was the timing and duration of the programme itself. By building up a good core collection of visual aids and slides it was able to tailor a selection to a particular need. The result had been crisp comprehensive presentations with the media coming back for more. Short slots were best.

The Executive Secretary mentioned that, possibly, the "Space '82" meeting might provide a suitable introductory springboard for something on these lines.

Mr. C. Hempsell (Associate Fellow) thought it would be better to start off at a lower level, i.e. a slot in, say, one or more local stations and then attempt to make it a more regular feature if it proved to be popular. This would be a campaign by stealth rather than a direct frontal assault.

The Chairman agreed that such a course should be worth pursuing, and, on that positive note, brought the meeting to a close.

SOCIETY NEWS

MORE SOLAR SAILING

One of the comments made at the "Solar Sail Race" meeting held on 17 November last year (reported in last month's *Spaceflight*) was that little seemed to have been published on the subject of using photon pressure to propel sail-carrying spacecraft.

Since then, a search through our own space library shows that Krafft Ehricke (BIS Fellow) considered the scheme in some detail in his book "Spaceflight, Vol. 2: Dynamics" (pub. D. Van Nostrand Co. Inc., 1962). A letter to Krafft revealed that he prepared the material in 1960/1 and intended to return to it later, although he was then sidetracked onto other projects. (But it did lead him to the concept of using large inflatable spheres as collectors for solar heat engines).

Dr. Ehricke illustrated sail-powered trajectories for probes to Jupiter and Saturn and estimated that a Mars craft with 100 lb of payload would require a sail area of almost 13,000 sq. ft.

(Transportation systems for the 1990's will be considered at a BIS symposium on 20 April; see 'Notices of Meetings' for details.)

VISITOR

Bob Powers, from Denver, arrived shortly after Christmas to sign our Visitors Book and to present us with a copy of his new book *The Coattails of God*. Bob was in London doing some promotion work on the British edition of one of his other books, *Planetary Encounters*, which has already appeared Stateside.

Bob, an astronomer by training and writer by bent, has been writing about Space subjects for 15 years now. He takes an optimistic view about US involvement in Space stations, even in the current cold economic climate. He thinks that current talk about SOF (Space Operations Facility) is warming up and that funding is within the bounds of possibility.

At present, Bob is currently researching an assignment for the Smithsonian Institution which will appear as a book in due course under the title of *Barnstormers of the Void*. The slightly peculiar title is based on the growth of private interest in Space. As examples, he points to the 200 or so newly-formed Space Societies in the States, the emergence of private interests in Space projects (one group is currently talking about buying up the entire payload space of the fifth Orbiter) and even proposals to provide Shuttle training for some hundreds of commercial pilots.

Bob Powers.

Dr. John Becklake (left) and John Harlow of the History Working Group.

HISTORY WORKING GROUP

The Council has now set up a History Working Group, under the Chairmanship of Dr. E. J. Becklake, and with John Harlow as Secretary.

The initial work of the new Group will be concerned with delving into the origins of British rocketry with the aim, eventually, of publishing a book under the auspices of the Society which sets out their findings. There is a good deal of work to be done in this area, not only as regards rocketry proper but also in the wider scope of the origins of astronautics in the UK.

As before, Dr. Les Shepherd, who also serves on the Committee, continues as the Society's Liaison Officer with the IAF History Committee and with similar groups abroad.

OBITUARY

TEOFILO M. TABANERA

With regret we record the death of Engineer Teofilo M. Tabanera, President and Founder of the Sociedad Argentina Interplanetaria.

Engineer Tabanera, by profession an electro-mechanical engineer, was an overseas member of the BIS of long standing, having joined our Society in 1946. In 1947, he formed the Argentina Interplanetary Society, which he acknowledged owed much to BIS inspiration and example and the advice and help given to him by the BIS Executive Secretary.

Eng. Tabanera was present on the historic occasion of the First International Astronautical Congress, when the foundation of the IAF was laid and, consequently, ranked among the pioneers of the Federation. He served as a Vice-President of the IAF over a total of eight years and was also a founder member of the International Academy of Astronautics.

In his native Argentina, Eng. Tabanera played an important role in official space activities. He founded the National Commission for Space Research, a governmental body which organised space research at universities and high altitude rocket development, under the sponsorship of the Argentina Air Force.

Teo will be remembered by all of us who knew him for his calm and friendly disposition and his pioneering spirit and burning enthusiasm for astronautics.

CORRESPONDENCE

Pioneering Family

Sir, I was very amused by the "modified" Pioneer 10 plaque shown in the November 1981 issue (p. 299) of *Spaceflight*. After only 10 year's flight, the human couple is shown as having acquired a family of three, and the man sports a beard.

The Pioneer 10 plaque was intended to show Extra-Terrestrial Intelligences in other star systems what we look like. However, it will take 80,000 years for Pioneer 10 to cover the distance to the nearest star (*New Scientist*, 23 July 1981, p. 205). What would the Pioneer 10 "family" look like then, I wondered?

To investigate the size of the Pioneer 10 family in 80,000 years' time I set up a simple computer simulation of human population dynamics. (Shades of mediaeval discussions of the number of angels able to stand on a pinhead, I thought.) The results were most surprising.

As your space wit decided, the family would have grown by three after ten years. Incidentally, two of the children would be boys and the middle child a girl (with any random number generator!)

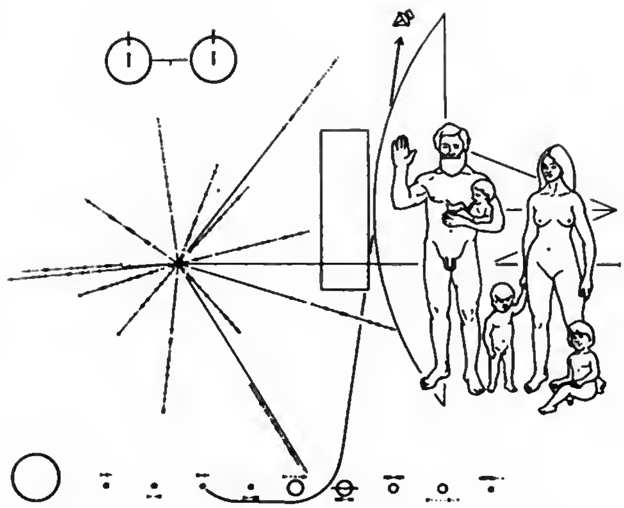
However, what happens after that depends critically on the productivity of the original couple. I judged that the man was aged 22 and the woman 21 at launch, because they would both have had to go through university training to become astronauts. As I had expected, the Pioneer 10 population exploded if there were no artificial restrictions on population growth, apart from a three-year breathing space between babies. (My computer expressed the situation appropriately by printing: "! TOO MANY REPEATS OF BIRTH ACTIVITY".)

What surprised me was how quickly it took to explode: only 159 years. By limiting the maximum family size to six children I managed to delay the crash to 170 years after launch. Most surprisingly though, if I extended the breathing space to four years between babies, or if I further limited the maximum family size, or if I brought forward the onset of menopause (male or female), then the population just died out in 123 years from launch.

Reluctantly, my conclusions are that, by the time some Extra-Terrestrial Intelligence studies the Pioneer 10 plaque, there will be nobody left aboard. My recommendations to the Pioneer 10 couple and their descendants for avoiding this sad state of affairs must be – as I am sure you will agree – unprintable in a family magazine such as *Spaceflight*.

TIM CRANT
Herts

P.S. My computer simulation cannot confirm that the man grows a beard.



The neo-Pioneer 10 plaque under question in the letter at left.

SCORE One to Us

Sir, David Howard's SCORE failure idea – that Atlas 6B attempted to carry out the mission (*Spaceflight*, November 1981, p. 329) – could have merit. Atlas 6B was identical in appearance and was reportedly a full range try before its destruction. A third Atlas B also looked the same (the conical nose cap). The original nose cone on the SCORE rocket was replaced at the last minute; if this can be ascertained for 6B, Howard's case would gain strength.

J. POWELL
Canada

Deane Davis, intimately involved with the Atlas and Centaur programmes for many years replies:

"It is interesting (and I write this on the 23rd anniversary of SCORE) to find that our little deceptions are still causing wonder. David Howard suspects that Atlas 6B could have been an unsuccessful attempt to carry out the SCORE mission. As one of the ringleaders in the execution of Project SCORE, let me set the record straight.

Atlas 6B was the first of a series of B series rockets whose purpose was to demonstrate operational-class performance at a very early stage in the Atlas development programme. These vehicles, dubbed "The Hotrods", were especially stripped of their heavy R & D instrumentation, modified variously in their airframes to reduce burn-out weight and fitted with the highest performance engines available. Several sets of featherweight nose cones (and supporting lightweight nose-adapter sections) were fabricated for use on the extremely long-range demonstrations. Atlas 6B was the first "Hotrod" and was never considered for an orbital flight – it was intended to fly at least 5500 nm.

Atlas 10B, the SCORE vehicle, was secretly groomed from the beginning as the orbital machine. Its back-up was 13B, flown later almost as an afterthought (it failed). The abrupt changes in configurations (and, therefore, mission assignments) were part of a plan to hide the intent to orbit from even the launch crew – a plan which succeeded."

Big Brother is Watching

Sir, I noticed that you reported my appearance in the *Hull Journal* of 9 April 1981, in your Society Publicity column in *Spaceflight* (October 1981, p. 280).

Unfortunately, the *Hull Journal* piece was misleading and inaccurate in a number of respects. I am ⅝ able to pick up communications with the space shuttle, but I do monitor foreign radio news reports in my home studio, as sources of information for my articles, I am currently working as a freelance journalist, specialising in aerospace, science, technology, medicine and certain aspects of defence and international affairs, I also produce radio programmes on a freelance basis.

I mention the Society as often as possible, particularly on BBC Radio Humberside. As the station's Science Correspondent, I appealed for new members in the Society when we discussed "Our Future in Space", on Monday evening, 7 December 1981, on an extremely popular teenagers' programme. Many thanks for producing an excellent magazine.

JONATHAN LEVY
Hessle, Yorks

Philosophy

Sir, It may be that I have missed the point of Mr. Koenig's letter in the November 1981 issue of *Spaceflight* (p. 331) but I fail to see how any of his comments have any bearing in the argument I expounded in my article "Why?".

Mr. Koenig describes logic as an "entertaining art," and the inference we are meant to draw from this is, I suppose, that it is consequently trivial. In his letter, however, Mr. Koenig tries to show that my arguments are invalid, that my beliefs are inconsistent or self-contradictory. Now, since logic is merely about the validity of arguments and the consistency of belief, Mr. Koenig would seem to be making use of that very standard which he claims to reject. Indeed, he cannot reject it, because it would be impossible to say what an alternative to it would be like. A mystique has grown up about formal logic which leads people who have neither studied nor understood it to believe that it has little or nothing to do with the way we ordinarily think; but as I have pointed out elsewhere, it is merely a refinement of certain natural modes of thought. How else might it have developed?

Similarly, Mr. Koenig clearly displays that he has not understood a central doctrine of one of those he criticises: Wittgenstein's reasoning behind his suggestion that it was unintelligible to talk of the Universe as a whole was not based on the simplistic arguments Mr. Koenig attributes to him, but on a rigorous study of the logical grammar of our language.

Neither does Mr. Koenig's argument about the external reference point to the Universe seem convincing: we possess no external reference point to the Universe and yet it is possible to know that it is expanding.

Finally, whether my article was my "swan song" or not I cannot say. It very much depends on whether I believe I have anything further worth saying.

MICHAEL TAYLOR
Oxford

I'm Alive!

Sir, A. Non (*Spaceflight*, November, 1981) refers to the pre-War BIS moonship and post-War Daedelus starship. There was "Another BIS Spaceship" - a nuclear-powered moonship conceived in the years just after WW II.

As for the design accompanying A. Non's letter, I assure you it has nothing to do with me. The design has evident technical merit, but I would have travelled in it only with the foot of the bed facing the exhaust, permitting bracing myself with my feet during periods of acceleration. I would also have been concerned about the directions of the cardinal points as indicated on the weathercock.

Where am I now? To the best of my understanding I live and work in the USA as a naturalised American.

STUART GREENWOOD
Maryland, USA

Bring back the Acorns!

Sir, I have just finished reading the splendid October issue of *Spaceflight*. Your saga of the building railings was intriguing and evidence of the enthusiasm and executive drive at the BIS!

Now is a good time to start a Finial Fund Foundation for, in the US, our squirrelly friends have already started gathering their acorns.

Might acorn finials be formed by casting in epoxy resin and painted? Attachment by a steel pin insert might be feasible. Anyway, enclosed is a cheque for the "finial fund", or such other use as you see fit.

F. C. DURANT, III
Washington, D.C.

SNIPPETS

Closer Than We Thought

Sir, I notice that Mars has been relocated to a position only 200 miles from Earth (*Spaceflight*, p. 297, November 1981) for Viking's convenience. Does this mean we can now visit it at our leisure?

JOEL POWELL
Canada

"Satellite Digest"

Sir, I must say how much I prefer the new-look "Satellite Digest." Its presentation of the information and illustrations makes it so much more readable than a tabular arrangement. Definitely a worthwhile improvement.

P. HARDING
Hemel Hempstead

WE ARE SEEKING MATERIAL ON NEW AND ADVANCED SPACE CONCEPTS

Our Society enjoys a high reputation as the originator or pioneer of many Space concepts. These reflect the inspiration of our members, hence our need for material of this kind to publish in our magazines.

The material we seek for each of our publications is as follows:

Spaceflight. Forward-looking articles covering future exploration and colonisation of the Solar System, new or advanced space applications, journies to the stars, etc.

Articles should be around 2,500 words in length, with good photographs and line drawings. We want *Spaceflight* to be as eye-catching and informative as possible.

Space Education. Already established as an intriguing magazine carrying material of educational value. If you are involved in any aspect of education, either in the UK or abroad, why not consider contributing news, comments or features? *Space Education* is unique. It brings together everyone with an interest in advancing public awareness on Space.

JBIS enjoys an enviable worldwide reputation. We are particularly interested in seeking material for the "Space Technology" issues on technical aspects of astronautics related to space vehicles, materials, communications, lunar and planetary studies, propulsion, guidance and control, instrumentation, experimentation, advanced concepts, applications, etc.

JBIS "Interstellar Studies" issues are particularly well-known for their authoritative articles on all facets of human expansion into the Cosmos.

JBIS "Space Chronicle" issues publish material in the range between *Spaceflight* and specialised areas. Every member will enjoy reading it. Full-length versions of articles in *Spaceflight* are often featured, along with many semi-historical features.

JBIS "Astronautics History" issues concentrate on the historical side of space exploration.

Help our Society to expand its reputation for advanced thinking and comprehensive coverage of space events by joining our band of Contributors.

If you wish to offer MSS for any of the above, please contact L. J. Carter at The British Interplanetary Society, 27/29 South Lambeth Road, London, SW8 1SZ.

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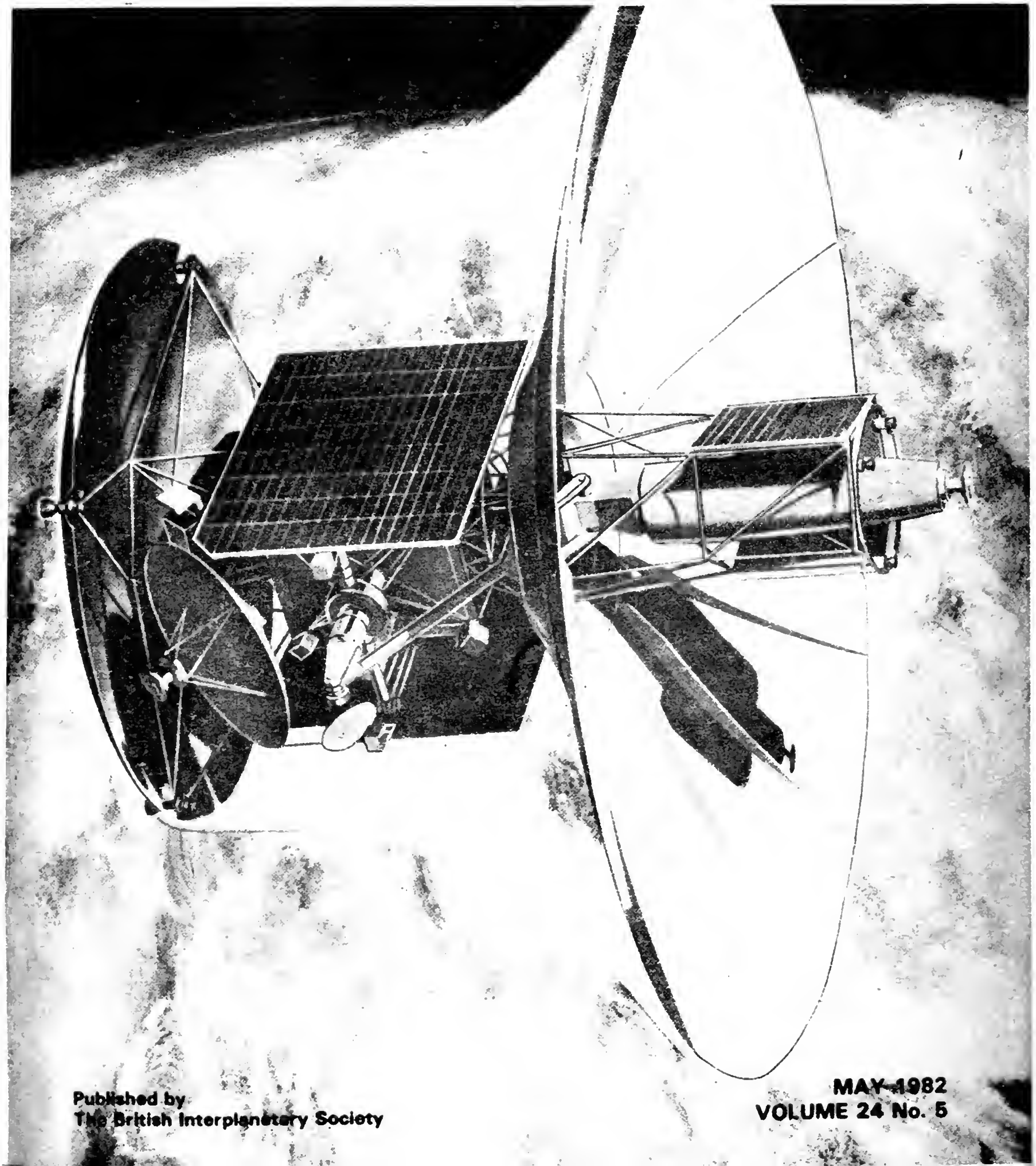

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G. V. Groves.

Assistant Editors:
L. J. Carter
A. D. Farmer

Managing Editor:
A. Wilson

CONTENTS

194 **The Maiden Voyage of "Columbia"** *John A. Pfannerstill*

202 **Japanese Space Plans for 1982–1985** *Neville Kidger*

205 **The Medical and Public Health Challenges of Space** *Oliver H. Loyd and Kennedy J. O'Brien*

208 **Space Report**

216 **Space Communications**

218 **Spacelab, Space Sickness and the Space SLED** *Mario Mutschlechner*

221 **John Young – One Man's Conquest of Space** *David J. Shayler*

225 **News from the Cape** *Cordon L. Harris*

226 **The Military Role in the Shuttle** *Gerald L. Borrowman*

230 **Satellite Digest – 154** *Robert D. Christy*

232 **Society News**

235 **Society Meetings**

237 **Join Us at Brighton for Space '82**

239 **Correspondence**

COVER

The Venus Orbiting Imaging Radar craft, intended for a 1988 launch, has been dropped from NASA's budget. VOIR was to have used "aerobraking" for the first time on a planetary mission. It would have entered a highly-elliptical orbit about Venus with its periapsis dropping into the upper reaches of the atmosphere. The resulting drag (visualised in the cover picture) would have gradually circularised the orbit and an engine burn could have then pushed the orbit up to 250 km to avoid further decay. Although VOIR has been cancelled, the mapping of Venus at high resolution may be considered important enough to fly a reduced mission.

Jet Propulsion Laboratory

MILESTONES

January 1982

26 ESA decides to go ahead with the development of its Ariane 4 launcher. This new version, due for a first launch in 1985, will carry a larger first stage, liquid and/or solid boosters (up to four) and a larger payload fairing.

February 1982

3 Space Shuttle Orbiter *Columbia* is towed from its Processing Facility into the Vehicle Assembly Building for mating with its External Tank and Solid Rocket Boosters. Launch of mission STS-3, with astronauts Lousma and Fullerton, is set for 22 March.

5 NASA formally accepts the first Spacelab unit – scheduled for launch as Spacelab 1 on STS-9 in September next year – from ESA. It will now be prepared for flight by NASA and McDonnell Douglas engineers.

12 INTELSAT announces that it will negotiate with the Hughes Aircraft Company for the Intelsat VI series of communications satellites. While the initial contract will be for five craft, the total value could amount to more than $1,000 million. The VI series, which is expected to go into operation from 1986, will be capable of relaying the equivalent of more than 30,000 telephone calls simultaneously as well as several colour TV programmes. INTELSAT called for proposals for the new series early in 1981 and in that July began assessment of the two proposals received, one from Hughes and the other from the Ford Aerospace and Communications Corporation. The satellite will be capable of launch aboard the NASA Shuttle or Europe's Ariane 4 launcher. The current Hughes version of Intelsat VI is a spin-stabilised satellite weighing over 3,500 kg (7,700 lb) measuring 3.6 m (11.8 ft) in diameter and standing 11.8 m (38.7 ft) high when fully deployed in orbit.

15 It is reported that Anatoliy Skripko, science and technology attaché at the Soviet Embassy in Washington, has acknowledged the development of a Soviet winged reusable spacecraft. He said the first launch could come within five years.

16 STS-3 is transferred from the Vehicle Assembly Building to Pad 39A, three days ahead of schedule. A countdown demonstration test involving astronauts Lousma and Fullerton followed. A cryogenics loading test is scheduled for 26 February and hypergolics will be pumped into the fuel tank on 4 March. If no problems are encountered during these critical functions, Page said that *Columbia* could be launched on 20 March, two days earlier than announced. That decision, he added, would await completion of the tests. Launch director George Page noted that it took 12 days of VAB processing to assemble the vehicle, compared to 18 days for STS-2.

16 NASA announces that Deke Slayton, one of the original Mercury astronauts, will leave the space agency on 1 March after 23 years' service. Because of a suspected heart condition, he was prevented from flying in space until the joint Soviet-American mission of 1975. He was then manager of the approach and landing tests of the Shuttle Orbiter *Enterprise* and the Orbital Flight Test programme of *Columbia*. Following retirement, he will act as an aerospace consultant.

22 Europe's first coast Earth station for maritime satellite communications is inaugerated at Eik in Norway. It will initially serve the Atlantic Ocean Inmarsat satellite but will switch to the Indian Ocean service later this year when a new station at Goonhilly takes over the Atlantic region.

25 The British Ariel 6 satellite, launched in June 1979 to study celestial X- and cosmic rays, is switched off because its pointing accuracy is no longer adequate. This is the last of the UK/Ariel satellites, a series stretching back some 20 years, but British astronomers are participating in the European Exosat X-ray observatory due for launch next October.

THE MAIDEN VOYAGE OF "COLUMBIA"

PART ONE

By John A. Pfannerstill

Who can forget the thrill of the first Space Shuttle launch from Florida, or of its landing two days later in California? Until mission STS-1 took off from Pad 39A at Cape Canaveral on 12 April 1981, an American had not been into space for almost six years. The impetus we saw in the days of the Apollo Moon landings is perhaps lost for ever, but who can deny that we now stand on the verge of the "real" space-age? It was made possible by the flight of Young and Crippen aboard "Columbia", a truly magnificent achievement.

Young (left) and Crippen arrive at Patrick Air Force Base, a few miles south of the space centre, after flying in from Houston for the STS-1 launch.

NASA

Pre-Launch Activities

Shortly after 07:00 GMT (all times are in GMT unless otherwise stated) on 12 April 1981, astronauts John Young and Robert Crippen were awakened in their crew quarters in the NASA Operations and Checkout (O & C) building on Merritt Island at the Kennedy Space Center in Florida. Following a brief physical examination, which showed that both men were in excellent shape, they donned blue NASA flight suits adorned with the NASA emblem and their own STS-1 mission patch. They headed over to the breakfast area for the traditional steak and eggs pre-flight meal, and were joined by several of their colleagues, as well as former Apollo 17 astronaut Harrison H. Schmitt.

Following breakfast, Young and Crippen received a GO from Shuttle Launch Director George Page to proceed to the Suiting Room in the O&C building, which they did at 08:20. The countdown was about mid-way through a two hour built-in hold at the T minus 2 hour 5 minute mark as they began the suiting procedure. Biomedical sensors were attached to their bodies to measure heartbeat, respiration and temperature, after which they began struggling into their rust-colored Emergency Ejection Suits (EESs).

The EES is identical to the suits used by pilots of the US Air Force's SR-71 reconnaisance aircraft, and are worn by Shuttle pilots during launch and reentry to provide emergency life support in the event of a malfunction serious enough to require ejection from the Orbiter. Using the suits, Young and Crippen could eject at any speed below Mach 3 and any altitude lower than 100,000 ft.

Before leaving the Suiting Room, the astronauts received a weather briefing over closed-circuit television from the Johnson Space Center in Houston. The forecast for the planned launch time of 12:00 was looking very good: temperature was 70°F, cloud cover minimal, wind speed fairly low and the relative humidity 55 per cent.

The low humidity was welcomed because it meant that the launch control engineers would not have to worry about excessive ice building up on the External Tank (ET). Ice normally coats the exterior because of the supercold liquid oxygen and liquid hydrogen inside it. If the humidity is high, the ice coating becomes thicker and there were worries that falling chunks could hit and damage some of the thermal tiles on the Orbiter. But television cameras out on the pad showed that there was no need to be concerned. In fact, a planned excursion out to the pad by an ice inspection team was canceiled.

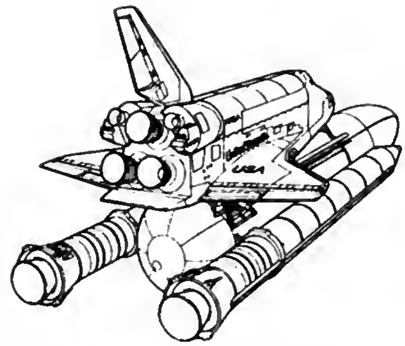
At 09:02, a cheer went up as Young and Crippen walked out of the O&C building into the glare of the television lights. Neither man was wearing his helmet, and each had an attendant walking behind to carry his portable air conditioning unit. The astronauts climbed aboard the "astronaut van" for the trip out to Pad 39A, where launch preparations for Columbia were moving along smoothly. After a short 15 minute drive, the van came to a stop at the base of the Fixed Service Structure (FSS) at 09:19.

The dining room scene on the morning of the second launch attempt. Young and Crippen are at the head table. Joining them are (left to right) crew trainer Richard Nygren, astronaut Karol Bobko, JSC Flight Operations Director George Abbey (behind Bobko), Shuttle orbital flight test manager Deke Slayton, Senator Harrison H. Schmitt, astronaut Ellison Onizuka, and KSC security officer Charles Buckley.

NASA

NORMAL ASCENT FLIGHT PROFILE

	Time (sec)	Altitude (ft)	Velocity (fps)
SRB ignition command	0.0	194	–
Lift-off	0.2	194	–
Mach 1	53.0	25,398	1,063 (rel)
Maximum dynamic pressure	54 0	26,328	1,080 (rel)
SRB jettison	131 7	165,604	4,193 (rel)
Normal 3-g limit	454 0	397,230	20,119 (inertial)
MECO command	512.4	386,622	25,591 (inertial)
External tank separation	529.9	388,872	25,666 (inertial)
OMS-1 ignition	632 4	414,206	25,638 (inertial)
OMS-1 cutoff	721 1	433,666	25,780 (inertial)
OMS-2 ignition	2640.4	794,227	25,336 (inertial)
OMS-2 cutoff	2717 4	795,865	25,471 (inertial)



The astronauts took the FSS elevator up to the White Room, donned their helmets and quickly went aboard *Columbia*, crawling on their hands and knees across an ingress bridge placed over the hatch rim. Both men were inside by 09:25 when the countdown was resumed at T minus 2 hours 5 minutes following the built-in hold.

Once aboard, they were assisted by astronaut Loren Shriver. He connected their communication and breathing lines, as well as the wires leading from the biomedical sensors.

The first voice communication with Young and Crippen in the cockpit took place at 09:32, indicating that the communications lines were hooked up properly. Problems were encountered, however, with the breathing lines. When the men lowered and locked their faceplates, they found that they could not breathe – they threw the plates open and gasped for air. Young momentarily worried that they could have a major problem on their hands which would force a second scrub, but Shriver quickly located the problem. A connector was not properly seated. He took care of the matter, and by 10:00 Launch Control was able to report that all was well.

Young and Crippen leave the KSC Operations and Checkout building for the drive out to Pad 39A.

NASA

After one last check of the cockpit, Shriver bade Young and Crippen farewell, and crawled out through the hatch at 10:18. Three minutes later, as the first indications of morning twilight began to lighten the eastern sky, the hatch was closed.

The astronauts, now alone in the cockpit, were enjoying the view from *Columbia's* wrap-around windows. They could see the stars overhead and as the sky began to grow lighter with the rapidly approaching Sunrise, they were able to enjoy the beautiful colours to the east. Crippen, who was on the side facing the ocean, was able to see pelicans flying about. He found the scene very peaceful and relaxing.

It was not all sightseeing, however. They had a very critical task to perform at the T minus 51 minute mark (10:40 GMT). At that point, the astronauts began the pre-flight alignment of their Inertial Measurement Units (IMU's). The IMU's provide a stable navigational reference to the Orbiter's five General Purpose Computers (GPC's), and it is extremely important that they are accurately aligned shortly before launch.

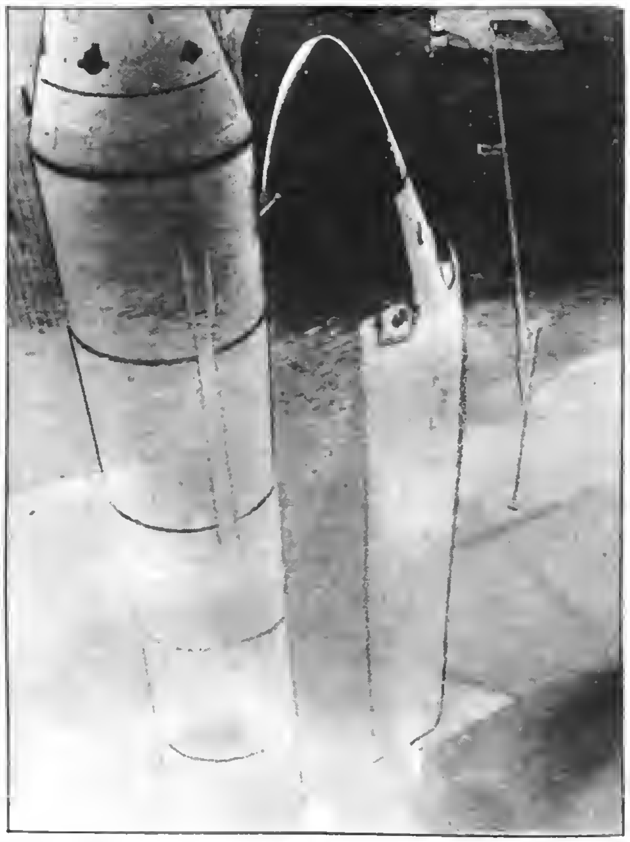
The entire IMU pre-flight alignment process takes about 50 minutes, and it was due to be completed during a 20 minute built-in hold at the T minus 20 minute mark. Also during this planned hold, the two NASA Shuttle Training Aircraft (STA's) went aloft with astronaut Joe Engle at the controls of one and NASA pilot Edward Mendenhall flying the other. Their task was to measure cloud perimeters around KSC to ensure that weather would be no problem in the event of an aborted launch.

As the countdown resumed at 11:30, the all-important check to ensure proper communications between *Columbia's* single backup and four primary computers was conducted. This was the area that had forced the scrub on 10 April, and when it was verified at 11:33 that all five GPC's were in proper synchronisation, a cheer went up from launch controllers in the Firing Room.

There was yet one more built-in hold scheduled in the countdown, a 10-minute period at the T minus 9 minute point. When the count was resumed for the final time at 11:51, all of the remaining countdown events were automatically under the supervision of the Ground Launch Sequencer (GLS). So many events have to be monitored in these last few minutes that human controllers cannot cope.

There was a manual task to be performed, however, which was not entrusted to the GLS. This occurred at T minus 5 minutes when Bob Crippen activated the Auxilliary Power Units (APUs). These are turbine devices powered by hydrazine which supply hydraulic power to drive *Columbia's* elevons, rudder and speed brake. In addition, they also drive the Main Propulsion System (MPS) engine gimbal mechanisms. APU startup was normal and on time.

Events were happening at an extremely rapid rate by this time. At T minus 3:30, the Orbiter aerodynamic control surfaces were run through a pre-arranged manoeuvring profile to help condition the hydraulic fluid being supplied to them



Columbia's launch as seen by an automatic camera mounted on the 275 ft level of the FSS.

NASA

by the APU's. Also at T minus 3:30, *Columbia* went on to internal power. At T minus 3, the three MPS engine bells went through a gimbal profile much as the aerosurfaces had done 30 seconds earlier. At T minus 2:55, the vent valve on the LOX tank was closed to allow tank pressurisation to begin, and at T minus 1:57, the same was done on the LH_2 tank.

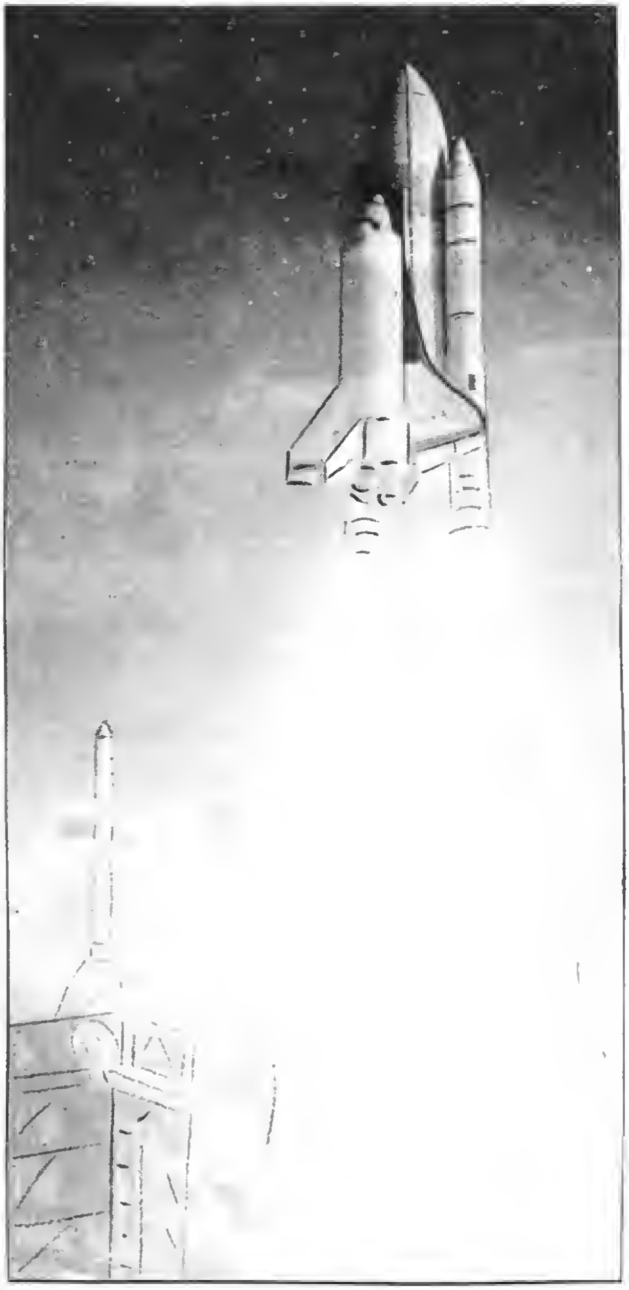
It was not until T minus 25 seconds, when *Columbia*'s computers took over supervision of the countdown from the CLS, that Crippen finally let the realisation sink in that this was *it* – they were really going into orbit. At that point, his heartrate shot up to a reading of 130 beats per minute, while John Young's stayed down in the mid-eighties.

Liftoff and Ascent

At T minus 3.46 seconds, *Columbia*'s three main engines started. Up in the cockpit, Young and Crippen heard what they later described as a "bang". There was some vibration, but nothing serious. They expected Solid Rocket Booster (SRB) ignition to produce a much more severe jolt. Crippen thought it would be similar to being shot off an aircraft carrier by a hydraulic catapult. But ignition proved to be a pleasant surprise. As the two rockets fired up, unleashing a combined total of 5.3 million pounds of thrust, the astronauts felt only a smooth, steady push upwards – not unlike a fast elevator ride.

First motion came at exactly 12:00:03.983 CMT on 12 April 1981.

Columbia's launch was a fantastic sight for the many spectators around the Kennedy Space Center. It moved upward much more rapidly than many veteran "bird watchers" were used to for a manned launch. It trailed two huge tongues of bright orange-yellow flame from the SRB's, and left a towering pillar of grey-white smoke in its wake which extended all the way back to the launch pad. The visual impact was similar to the spectacular night launch of Apollo 17 in 1972.



Launch!

NASA

After clearing the FSS, *Columbia* began moving through a programmed roll and pitch manoeuvre to put it in the proper attitude and heading for orbit. On Pad 39A, the astronauts' heads had been pointed almost due south but as they twisted around 120 degrees to the right they were pointing northeasterly. *Columbia* then began pitching over gradually onto its back, carrying the vehicle out northeasterly over the Atlantic.

In order to ease the passage through the period of maximum aerodynamic pressure (Max-Q), expected at about 50 seconds Mission Elapsed Time (MET), the GPC's commanded the three main engines to reduce thrust. They had been burning at maximum thrust since ignition back on the pad but at 32 seconds MET, the throttle was cut to 65 per cent. After Max-Q passage, the engines came back up to full thrust.

Just prior to Max-Q, at about 40 seconds MET, the astronauts noticed material flying past their forward windshield,

apparently coming from the ET. It bounced off the windshield and flew back over the top of the Orbiter, leaving streaks on the windows. Crippen said later that he believed the material was either ice or particles of the spray-on foam insulation coating the ET.

In *Columbia*'s cockpit, Young and Crippen were having a fairly rough ride, although not nearly as rough as they had been expecting based on their experience in the Shuttle Mission Simulator[1]. Nor was the ride as loud as they had expected.

While *Columbia* was flying under the power of the SRB's, on-board and ground readings showed the vehicle to be in a 5 per cent steeper climb than programmed. Although the problem was puzzling, it was not considered to be dangerous because the guidance system could easily compensate for the "loft" after SRB separation. The problem had to be solved though because a steep climb on operational flights would have reduced the payload capability.

Shortly after 2 minutes MET, the SRB thrust began to drop off, and at 2 minutes 11 seconds the astronauts saw a breathtaking orange-yellow flash through their windows as the eight SRB separation rockets fired. Onlookers lining the Florida beaches could clearly see the two pencil-thin rockets fall away from the climbing craft. The SRB's fell into the Atlantic about 5 minutes later, ready to be picked up and refurbished for re-use on a later Shuttle flight[2].

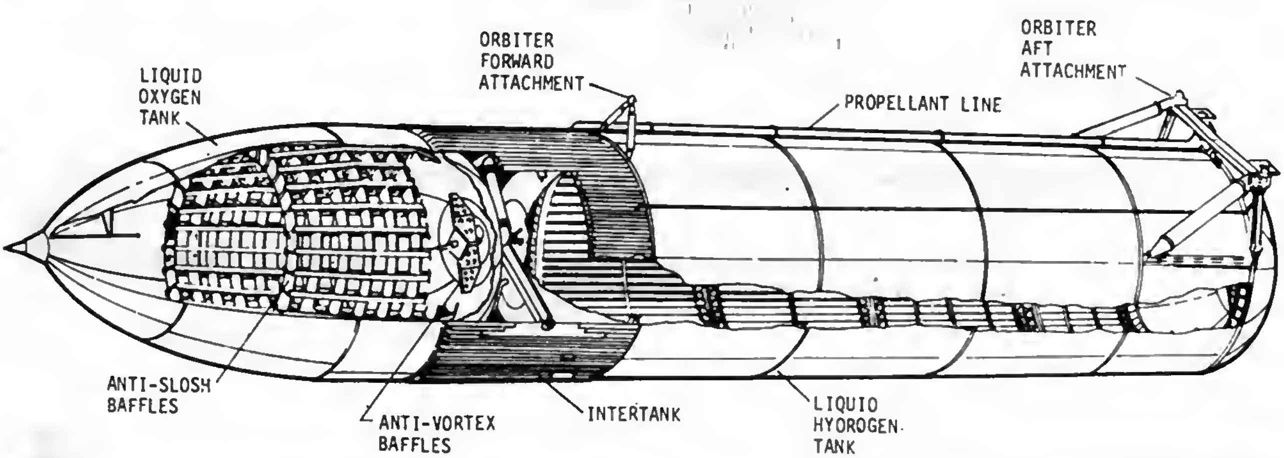
With the SRB's gone, the extra altitude gained had to be taken out. The guidance system was performing superbly and the vehicle was back on track in a very short time. Main engine performance was also excellent, in fact, it was slightly better than expected.

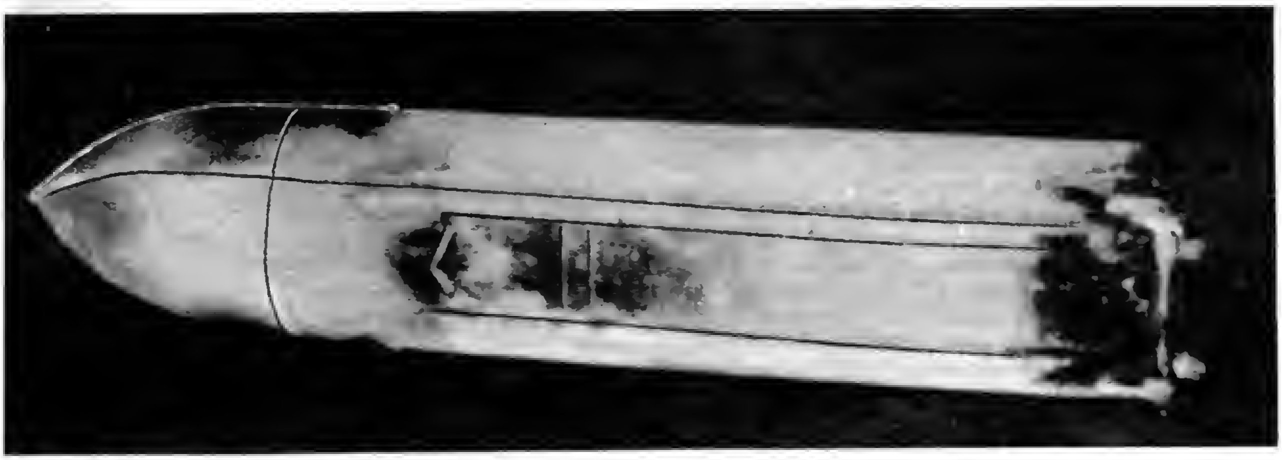
During the ascent, capcom astronaut Daniel Brandenstein periodically informed Young and Crippen that they were entering different abort mode capabilities. Up until about 4 minutes MET, any major systems failure would have dictated a Return-To-Launch Site (RTLS) abort. RTLS is an extremely complicated and time-critical manoeuvre designed to turn the Orbiter/ET stack around from its eastward course and start it heading back to the landing strip at the Kennedy Space Center[3]. *Columbia* was nearing the point at which it would be too far downrange to fly an RTLS, and at 4 minutes 20 seconds MET, Brandenstein told the astronauts they were "negative return," meaning that any abort from that time on would have to be forward, bringing them down on contingency landing strips at either Rota Naval Air Station in Spain, or Northrup Strip in New Mexico.

As part of the programmed ascent trajectory, the Orbiter/ET combination was pitched over into a shallow "dive", with the astronauts' heads pointed toward the Earth and *Columbia*'s nose pointed 4 degrees below the horizon.

As a by-product of the dive, Young and Crippen got their first breathtaking view of the Earth. Until that point, their windows had been pointed upward at the blackness of space. "What a view, what a view!," Crippen exclaimed just after 5 minutes MET as the dive got underway. The Orbiter's six windows afforded the astronauts a nearly 180-degree view, much better than on previous manned space flights.

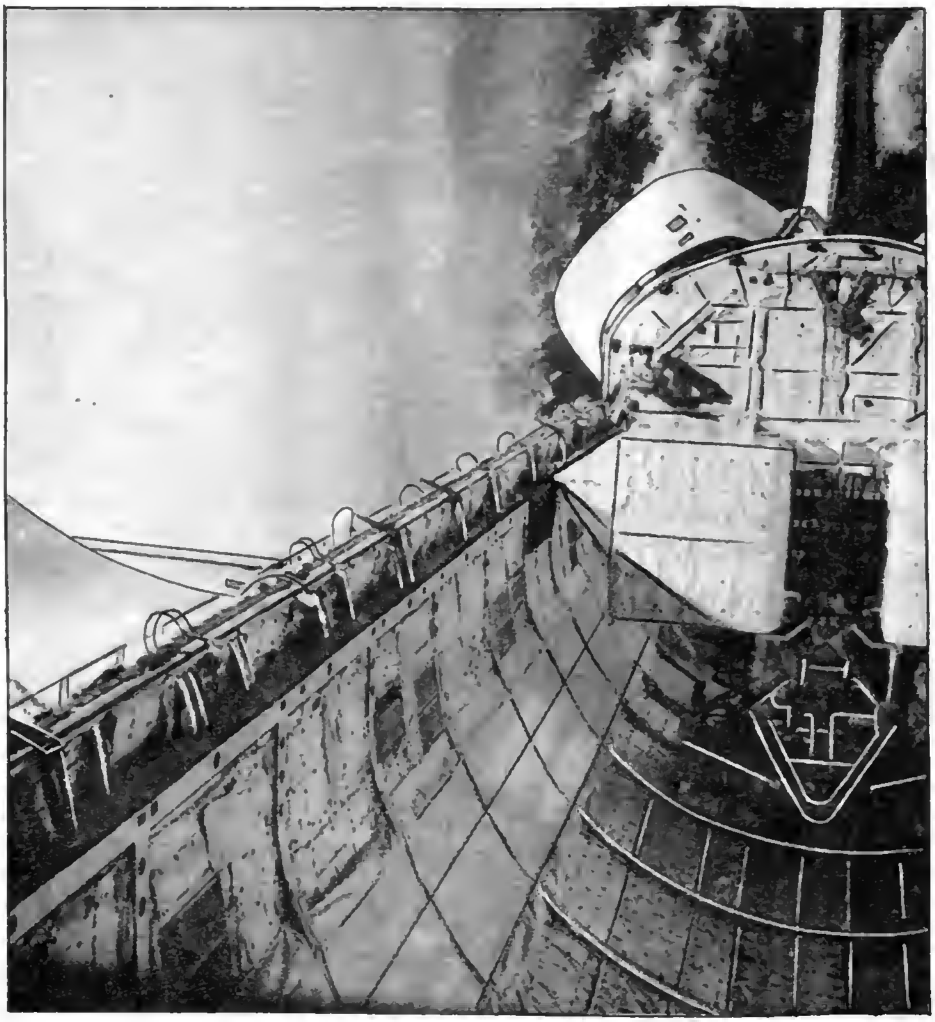
As *Columbia* continued in its shallow dive to the planned Main Engine Cut-Off (MECO) altitude of 63.9 nautical miles it was accelerating rapidly. As engine cutoff approached, the main engines were throttled back so that the loads would go no higher than 3g. The astronauts reported the throttling to be very smooth.





Separation of the External Tank as viewed by a camera in an umbilical bay. Note the charring.

NASA



Columbia's open payload bay as seen from the aft flight deck windows. The Development Flight Instrumentation (DFI) package can be seen midway down the bay. Note the missing tiles off the OMS pod.

NASA

As the three main engines shut down at 8 minutes 34 seconds MET, the astronauts found it to be very gentle. For Young, MECO was much smoother than he had remembered from his previous Gemini and Apollo flights.

The entire ascent had been perfect. *Columbia* was at an altitude of 63 nm, travelling at a velocity of 25,670 feet per second (fps), and climbing at a rate of 220 fps. All the figures were well within limits.

OMS Manoeuvres

At MECO, *Columbia* was in space, but not yet in orbit. If nothing further were done, it would follow a long, arcing ballistic path before reentering the atmosphere over the Indian Ocean. The cutoff velocity targeted for MECO had purposely been kept short of orbital speed in order to ensure that the ET would reenter and break up over the ocean away from major land masses. Most notably, NASA wanted to keep it away from Australia, which was still smarting after being hit by Skylab debris in 1979.

In order to push *Columbia* into orbit, there were to be two burns of its Orbital Maneuvering System (OMS). The first of these, called OMS-1, was to take place immediately after ET separation and would put the spacecraft into an orbit of 57×130 nm. The second burn, OMS-2, would take place half-way around the world from the first, at the 130 nm apogee point. The effect of OMS-2 would be to raise the 57 nm perigee up to 130 nm and thus make the orbit circular.

The first order of business, however, was to release the spent ET. This took place automatically about 20 seconds after MECO; the tank separated cleanly, so smoothly the astronauts could not feel it.

Before OMS-1, the astronauts wanted to put some additional distance between them and the ET, so Young took over manual control for the first time. He used the Reaction Control System (RCS) jets to move the vehicle sideways along the ground track to take it north of the ET.

Safely away from the spent tank, Young manoeuvred *Columbia* into the proper attitude for OMS-1. Ignition of the twin 6,000-lbf OMS engines came right on time at 10 minutes 37 seconds MET. The engines burned for 1 minute 27 seconds, increasing *Columbia's* velocity by 164.7 fps. This was enough to put it into a 57×132 nm orbit.

At 12:12 GMT, just as the OMS engines were shutting down, *Columbia* moved out of range of the Bermuda tracking station. The next station to acquire the signal would be Madrid in Spain but before then, Crippen had a couple of tasks to perform. The first of these was to shut down *Columbia's* APU's. These units have a limited supply of hydrazine which had to be preserved for reentry. The second task was to close the ET umbilical doors on the Orbiter's belly. The door covers are layered with the black high-temperature TPS tiles and in order for the spacecraft to reenter safely the doors have to close tightly. They did.

Columbia passed into and out of contact with Madrid, and at 12:36, it was within range of the Indian Ocean Station (IOS). While over the IOS, Young and Crippen took some time out to comment on the spectacular sight: "Well, the view hasn't changed any," Young said, "it's really something else!" Crippen

added, "I tell you, John has been telling me about it for three years, but ain't no way you can describe it. It's hard to get my head in the cockpit here and do my procedures."

Crippen also mentioned that, despite all the efforts to keep the Orbiter clean, there was debris floating around the cabin. He promised to use a vacuum cleaner later to clean it up.

As *Columbia* moved out of contact with the IOS, the time for OMS-2 ignition was rapidly approaching. At exactly 44 minutes MET, the two OMS engines ignited for the second time. Again, the burn was perfect. The 1 minute 17 second manoeuvre added 136.5 fps and put *Columbia* into an orbit of 133.5×132 nm.

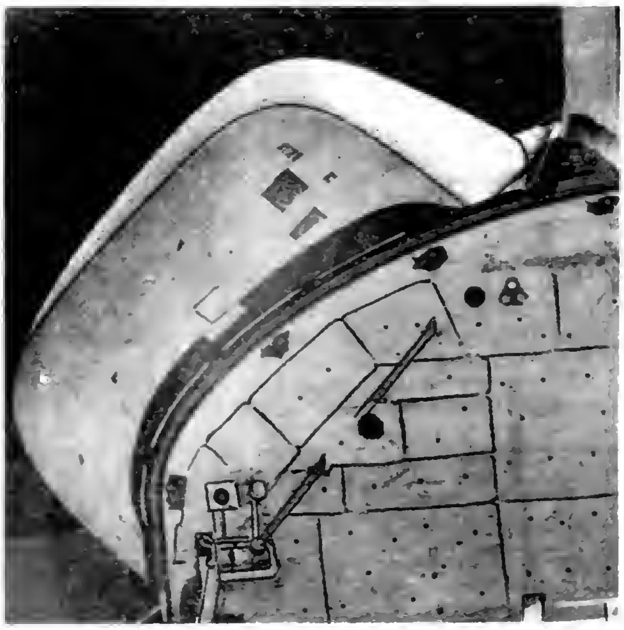
With the successful OMS-2 burn, *Columbia* was at last in a good, stable orbit. The next item on the flight plan called for Crippen to re-configure the computers for the on-orbit phase of the flight.

Just before liftoff, the GPC's had been loaded with a program known as "OPS-1." This software package controls all launch and abort functions but now that the ascent was safely over a new computer load, OPS-2, was being put into use. The OPS-2 software consists of all the basic computing and diagnostic functions that would normally be used by a Shuttle crew while in orbit. Four of the Orbiter's five GPC's were loaded with OPS-2, while the fifth had OPS-3, the normal reentry and landing software. OPS-3 would be kept in at least one of the computers at all times as a precautionary measure in the event of an emergency landing.

By 13:01, as *Columbia* moved into acquisition range of the Orroral Valley (Australia) tracking station, Young and Crippen were busy unstrapping themselves from their ejection seats. Space rookie Crippen was careful to avoid rapid head movements in his early free-floating encounter with zero-g. He was going to be far too busy to become sick, so as an added precaution he had taken an anti-motion sickness pill before launch. Young didn't worry quite as much about zero-g since he had had no problem with motion sickness on any of his previous flights. As it turned out, both Young and Crippen felt fine for the entire flight.

John Young in the commander's seat.

NASA



A closeup of one of the OMS pods showing an area of missing tiles. Just below is the aft payload bay television camera.

NASA

Payload Bay Door Tests

After getting out of their seats, the astronauts floated back to the aft flight deck area. There they began running through a checklist in preparation for the opening of *Columbia*'s two huge Payload Bay Doors (PLBD's).

This was an extremely critical operation. Inside the doors are large radiators for carrying heat away from the Orbiter. If it became impossible to open the doors, *Columbia* would be forced to reenter and land within several hours, relying on the limited supply of secondary cooling provided by the flash evaporator system.

While engineers were primarily interested in simply opening the doors for cooling purposes, there were also a series of tests to be carried out designed to evaluate door performance under flight conditions.

Crippen began the test procedure by releasing the PLBD latches. There are four latches on each bulkhead and 16 latches down the door centreline. He simply opened all of these latches, one at a time, without opening either door, and then closed them all again to make sure they were working properly.

He then started releasing the latches a second time in preparation for opening the starboard door. Meanwhile, *Columbia* moved into contact with the Tula Peak (New Mexico) station at 13:31 to begin its first 16 minute pass over the United States. The astronauts gave an update to Mission Control on their progress. "We're just about at the point where we're ready to open the right door," Crippen told capcom Brandenstein[4].

Moments later, Crippen opened the starboard door and the payload bay flooded with bright Sunlight. *Columbia* was still upside down and the astronauts could see the Earth moving past 130 nm below them. "You're missing one fantastic sight," Crippen told Brandenstein, "here comes the right door and, boy, that is really beautiful out there."

"We appreciate the great view updates," lamented Brandenstein, who had nothing to look at but a blank TV screen. Mission Control was unable to receive live television until the Orbiter reached the Merritt Island (Florida) station at about 13:36. Young was recording everything on the on-board video tape recorder, however, so nothing was lost.

"We can see a little trash floating out the payload bay, but nothing really all that significant," Crippen said, "All the

latches work fine and the door looks like she's doing her thing."

Only the starboard door was opened on this first test; the port door remained closed. By the time the live TV came up in Mission Control, the starboard door was already closed again. Young was using a theodolite to sight along the door centreline to ensure that no warpage had occurred in the starboard door during the time it had been open. There was none.

"Okay," Crippen said, "doors all latched up beautiful. We are getting ready to open them back up again."

To do so, Crippen released the latches once more. But before either door could be opened to give television viewers on Earth a look outside, *Columbia* passed out of range of Merritt Island at 13:43 and the picture was lost. The crew still had voice contact through Bermuda for another four minutes, but additional television had to wait until the Madrid pass.

Missing Tiles

When *Columbia* came into contact with Madrid at 13:52, both doors were fully open. The down-link TV was sending live pictures to Mission Control from three remote-controlled cameras in the payload bay, showing stunning clarity.

As the cameras panned around the bay, viewers on Earth were startled to see several squarish dark spots on the surface of both OMS pods. As the forward camera zoomed in on one of the pods, Crippen confirmed what many were already suspecting.

"Okay, we want to show you our OMS pods," he said, "we do have a few tiles missing off both of them. Off the starboard pod it's got basically what appears to be three tiles and some smaller pieces and off the port pod looks like I see one full square and looks like a few little triangular shapes that are missing and we're trying to put that on TV right now."

The missing tiles caused quite a stir on Earth among the news media and the general public. Fed on horror stories of the possible consequences of just one tile falling off of a critical area of the Orbiter, many people were convinced (despite NASA's assurances to the contrary) that the missing tiles would cause *Columbia* to burn up on reentry. This was not the case, however. The pods would be cool on reentry compared to the

Bob Crippen and *Columbia*'s two overhead windows. The cargo bay instrument panels can be seen at right.
NASA

underside of the Orbiter and the leading edges of the wings.

The astronauts were unable to see *Columbia*'s underside, so they had no idea whether tiles were missing there or not. But Young did look over as much of the spacecraft as he could from the windows.

"From what we can see of both wings and leading edges," he said, "all those are fully intact."

Young and Crippen were not worried about the underside. Crippen felt that the OMS tiles probably popped off due to pressure flexing of the pods during launch. On the underside of the vehicle, which was flatter and more uniformly shaped than the OMS pods, he believed that the tiles were probably unaffected by the flexing.

Nevertheless, NASA made arrangements to photograph the underside with high-resolution US Defense Department cameras. The ground-based cameras reportedly had good enough resolution to spot a missing tile as the Orbiter flew overhead. The equipment is highly classified, and none of the pictures were released[5].

The missing tiles easily stole the show during the television transmission through Madrid, and it was easy to lose sight of the important fact that the PLBD's were open and the radiators successfully deployed. There was now no need to worry about overheating.

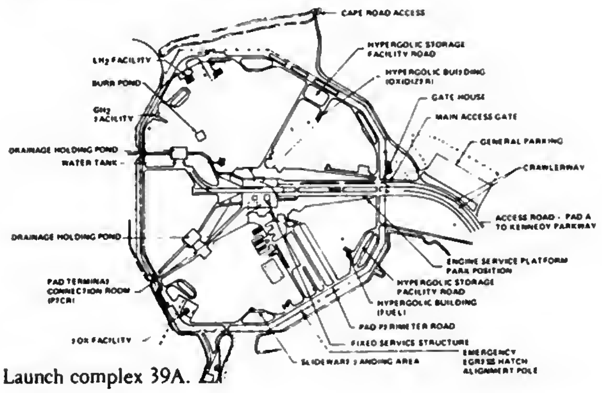
IMU Alignment

At 13:56, Madrid lost the signal and Young and Crippen moved on to the next item on their flight plan – an in-flight alignment of the IMU's. As mentioned earlier, the IMU's had been aligned prior to launch, but they do tend to drift and have to be re-aligned periodically so that the GPC's always have an accurate fix on the Orbiter's location. The plans for STS-1 called for three IMU alignments daily, and Young and Crippen were about to do the first of these. If it did not come off properly, mission rules dictated that they must return to Earth.

The alignment process made use of the Orbiter's star trackers, but Young and Crippen were also going to evaluate the use of the Crew Optical Alignment Sight (COAS) as an alternative for obtaining star sightings. The COAS was

Table 1. STS-1 Flight Plan Activities Mission Day 1

GMT	MET (DY/HR:MN)	ORBIT	EVENT
12:00	00/00:00	–	Liftoff
12:08	00/00:08	1	Main Engine Cutoff (MECO)
12:09	00/00:09	1	ET Separation
12:10	00/00:10	1	OMS-1 Ignition (130×55 nm)
12:44	00/00:44	1	OMS-2 Ignition (130×130 nm)
12:50	00/00:50	1	GPC Configuration (OPS-1 to OPS-2)
13:20	00/01:20	1	Begin PLBD Latch & Door Tests
14:20	00/02:20	2	Radiator deployment
14:25	00/02:25	2	COAS Calibration
14:45	00/02:45	2	IMU/Star Tracker tests
15:15	00/03:15	3	Fuel Cell Purge
15:35	00/03:35	3	EES Doffing
16:00	00/04:00	3	Orbiter systems activation
17:00	00/05:00	4	Meal period
18:22	00/06:22	5	OMS-3 Ignition (150×130 nm)
19:05	00/07:05	5	OMS-4 Ignition (150×150 nm)
19:30	00/07:30	6	Flight Control System Checkout – Part I
20:20	00/08:20	6	RCS Jet Test
20:40	00/08:40	6	IMU Alignment
21:20	00/09:20	7	TV of Flight Status Report
21:50	00/09:50	7	Meal period
23:00	00/11:00	8	IMU Alignment
23:15	00/11:15	8	COAS Calibration & Alignment Verification
23:55	00/11:55	9	Fuel Cell Purge
00:15	00/12:15	9	Pre-sleep Activities
01:00	00/13:00	9	Begin sleep period (7hr 50min)



Launch complex 39A.

mounted in Young's forward cockpit window, and was considered to be strictly a backup to the star trackers.

The IMU alignment was accomplished at 14:50 while the craft was flying in darkness over the Pacific Ocean. There were no problems and everything went so well that the astronauts found themselves about 10 minutes ahead of the flight plan.

Columbia came into contact with the Buckhorn (California) station at 15:02, beginning its second crossing of the United States. During this pass, there was just one more event remaining in order to allow Young and Crippen to remain in orbit longer than just a few hours. The fuel cells had to be flushed of impurities – a relatively simple operation, but a critical one. If the purge were not accomplished, the cells' power output would be seriously impaired and an early return necessary.

"Okay," Crippen said, "I'm CO to initiate that purge whenever you guys are."

"Roger, we're ready to go," Brandenstein responded.

Several minutes later, the operation was finished without any problems. Everything required to set the Orbiter up for an extended stay in orbit had been accomplished – the GPC re-configuration, the PLBD opening and radiator deployment, the IMU alignment and now the fuel cell purge.

According to the flight plan, Flight Director Neil Hutchinson took a poll of his "Silver" flight controllers in the Mission Control Center to decide whether or not to allow Young and Crippen to stay in space. The decision was GO.

"Columbia, Houston," Brandenstein radioed at 15:16, "you guys did so good we're going to let you stay up there for a couple of days. You're CO for on-orbit."

"Let's go for on-orbit," Young responded enthusiastically, "this thing is performing just outstanding."

As *Columbia* passed out of range of the tracking stations across the United States at 15:21, Young and Crippen found themselves with a ship-shape spacecraft.

To be continued

REFERENCES AND NOTES

1. Craig Covault, "Shuttle Launch Ascent Faces Formidable Challenges." *Aviation Week and Space Technology*, 29 September 1980, p. 48-62.
2. Both SRB's were successfully recovered about 151 nm downrange from the launch pad. Their landing points were about 16 to 18 miles away from the two recovery ships *Freedom* and *Liberty*. *Freedom* recovered the port SRB and towed it back to Cape Canaveral, while *Liberty* recovered the other. As an unexpected bonus, the nose cap from one of the two boosters was also recovered, as were four of the six parachutes. (One 'chute was missing from each rocket.) The two SRB's were in surprisingly good condition. There was no severe heat scarring – just a slight "tanning" on each end. The telemetry wiring was still taped securely in place, and the white paint was still on each booster. The nozzles on both were slightly bent (probably due to the water impact), but both were pronounced to be repairable.
3. Craig Covault, "Shuttle Aborts Pose New Challenges," *Aviation Week and Space Technology*, 15 October 1979, p. 39-45.
4. There was some confusion as to which door was which in many accounts of the flight. The starboard door is the door to the crew's left as they face the tail of the Orbiter. In this transmission, Crippen was referring to the starboard door and by calling it the "right" door, he was probably referencing things to a view looking forward from the tail.
5. It was discovered later that the Orbiter was also photographed by a US Air Force KH-11 reconnaisance satellite within an hour of the "missing tile" television broadcast. Crystal-clear photos of *Columbia*'s underside were reportedly in the hands of engineers before 16:30 GMT, when the "Silver" team went off duty. This may have accounted for Flight Director Neil Hutchinson's surprising confidence at the change-of-shift press briefing that no tiles were missing from critical areas of the Orbiter. For obvious security reasons, NASA has not released the photos, and neither denied or confirmed that they were ever taken.

SOCIETY EDUCATIONAL TOURS

Halley's Comet – April 1986 – 14 days duration

Owing to the likelihood that Halley's Comet will prove to be a disappointing object when viewed from the Northern Hemisphere, if it can be seen at all, the Society plans to organise a trip to South Africa to view the comet from the Southern Hemisphere. Present indications are that the most favourable time will be the first week in April 1986.

The Society will arrange travel and motel accommodation at the best possible rates.

We plan to provide each participant with a copy of a Society booklet (provisionally entitled "Halley's Comet Excursion") containing a history of previous Comet apparitions, with space for observations and personal notes about the expedition itself, together with star maps and other details of the 1986 return.

Forms for provisional registration are now available from the Executive Secretary. Please enclose a stamped addressed envelope.

JAPANESE SPACE PLANS FOR 1982–1985*

By Neville Kidger

Introduction

In 1981 Japan launched three satellites, covering scientific, techr.ological and meteorological activities. The launchings are indicative of the aggressive programme of space satellite and launcher development which will, over the next few years, see Japan orbit ten more payloads with their own rockets from launch sites in Japan.

The development of satellites and launchers in Japan is divided between the Institute of Space and Astronautical Sciences (ISAS) of Tokyo University, and the National Space Development Agency of Japan (NASDA). ISAS is charged with the responsibility of preparing and launching small scientific satellites whilst NASDA looks after the development and procurement of large satellites to suit a number of the nation's needs in the communications and meteorological fields. NASDA also handles the development of large launch vehicles (with US technical assistance) for orbiting these satellites.

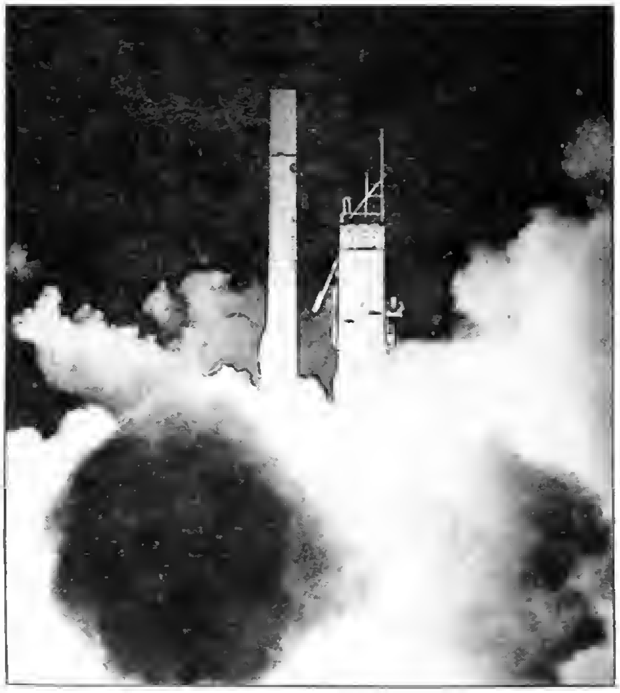
Launchers

Currently, the Japanese satellite launch vehicles consist of the Mu-family, for orbiting scientific satellites, developed by ISAS, and the N-family, for orbiting applications satellites mainly to geostationary transfer orbit. NASDA is continuing the development of the H-1A rocket to meet the demand for launching larger satellites from the latter half of the 1980's.

ISAS Launchers

The Mu-family has been successfully upgraded throughout the 1970's. The current version is the Mu-3S which is a 23.8 m tall three-stage solid-propellant vehicle with eight small strap-on boosters around the base of the first stage. The Mu-3S is capable of placing about 300 kg into a low-altitude orbit.

* *Previous reviews of Japanese space activities appeared in the March 1976, November 1976 and October 1981 issues of* Spaceflight.

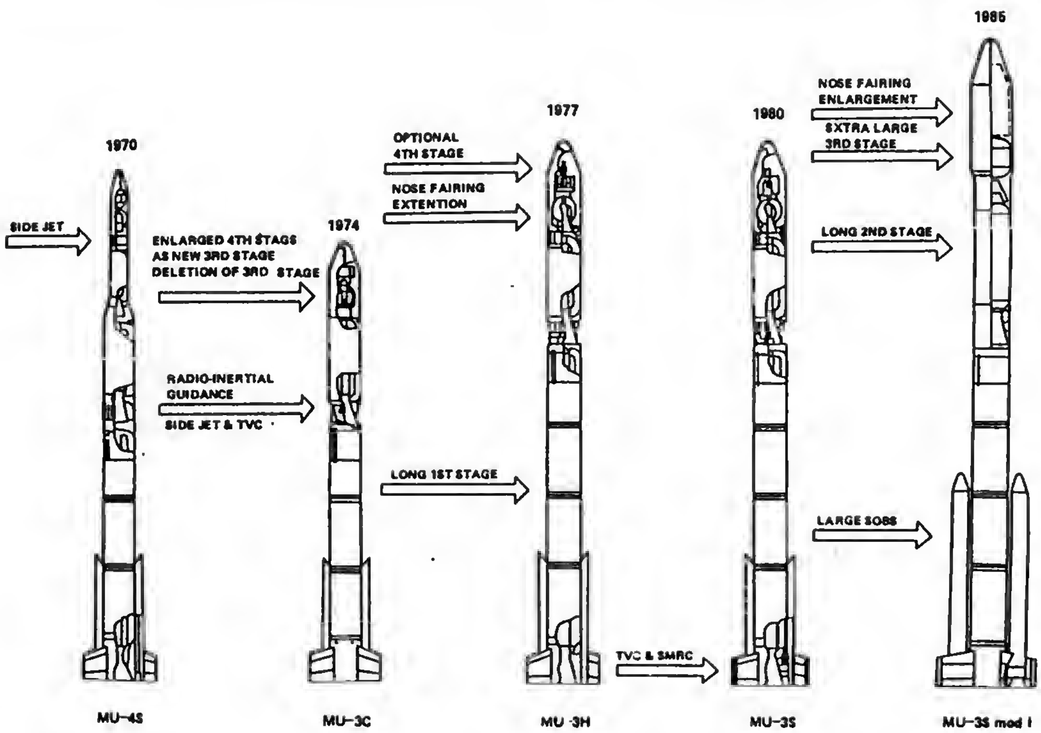


Launch of the second N-2 vehicle, 11 August 1981.

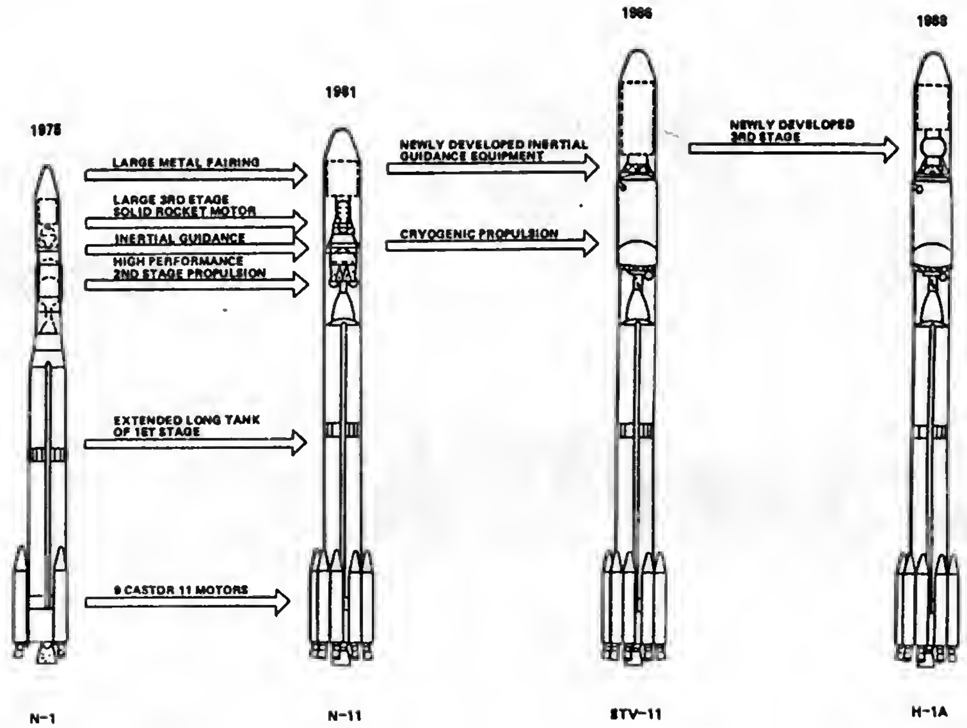
NASDA

It features a full guidance and control capability by means of secondary fluid injection thrust vector control systems. The Astro-B and Exos-C satellites are currently scheduled to be orbited by this rocket.

The Mu-3S mod. 1 launcher is an improved version of the Mu-3S and also consists of three solid-propellant stages. However, at 28 m tall, it will have the capability of launching up



The solid-propellant Mu launch vehicle family.



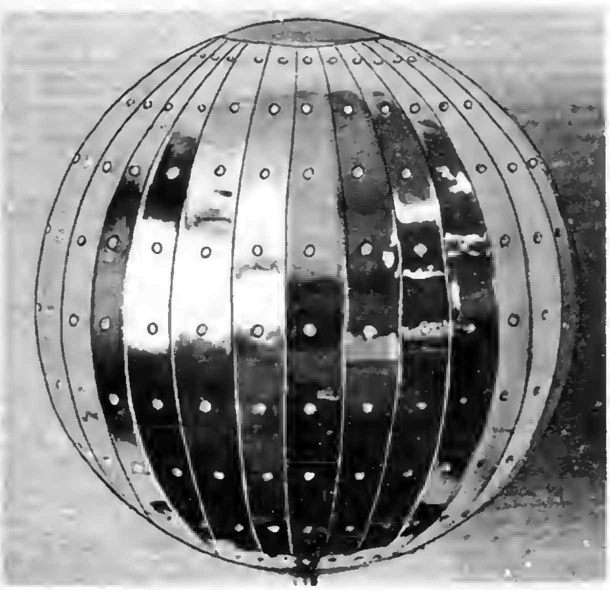
Development of the Japanese N and H launch vehicle family, based on the American Delta.

to 670 kg into a low-altitude orbit through thrust augmentation of the second and third stage motors and the addition of two much improved strap-on boosters to replace the eight on the Mu-3S. Following launch of a test satellite to verify the performance of the vehicle, the Mu-3S mod. 1 will launch the Planet-A and Astro-C satellites. The test satellite is scheduled for launch in early FY-1984.

NASDA Launchers

NASDA's Delta-class N-1 launcher is capable of placing about 130 kg into geostationary orbit. The first two stages are liquid fuelled while the third is a solid-propellant stage. Only one, carrying the ETS-3 satellite, remains to be launched.

The N-2 launcher is capable of lifting about 350 kg into geostationary orbit due to the lengthening of the first stage (amongst other improvements). The H-1A launcher, being developed as a three-stage launcher with a liquid oxygen/liquid hydrogen second stage, will be able to place about 550 kg into geostationary orbit.



Model of the Geodetic Satellite balloon under study for possible launch later this decade (see *Spaceflight*, January 1982, p. 17).

NASDA

Satellites Planned for Launch

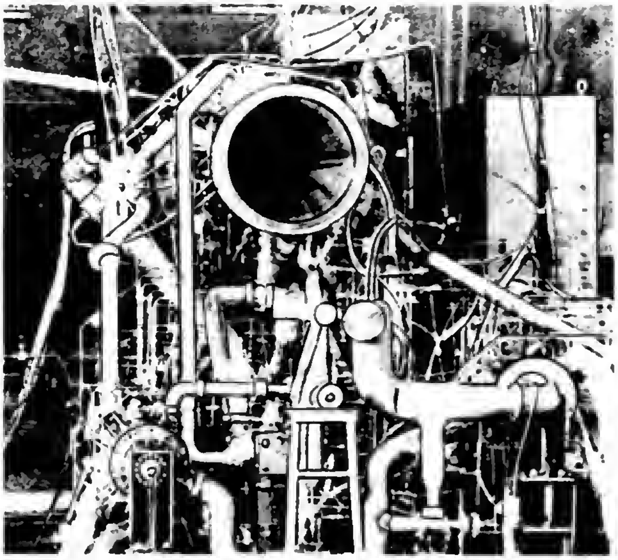
Since 1970, ISAS and NASDA have launched a total of 21 satellites. The plan for the period up to the end of FY 1985 envisages the launch of four scientific satellites, six applications satellites and one test satellite. In addition, ISAS is providing a principal investigator and major hardware for the Sepac project due to be flown aboard Spacelab 1.

ISAS's 4 scientific satellites are:

Astro-B. The eighth scientific satellite is being prepared as a follow-on to the fourth scientific satellite *Hakucho*. It will perform two-dimensional imaging of celestial X-ray sources, including nebulae; galaxies and burst sources, with high temporal and spectral resolution. The box-shaped satellite is powered by four solar paddles and will weigh 180 kg. Launch is planned by mid-1982 into an orbit ranging from 350 to 600 km at an inclination of 31 degrees.

Exos-C. The ninth scientific satellite, is an aeronomy satellite dedicated to the Middle Atmosphere Programme (MAP) of ICSU. From an altitude of between 300 to 1000 km, inclination 65 degrees, the satellite will observe phenomena in the stratosphere and the mesosphere (altitude 10 to 130 Km) using optical instruments. The data will allow further study of the ionosphere's curious behaviour over the South Atlantic Geomagnetic Anomoly which was found by the third scientific satellite *Taiyo*. Launch is planned for late 1983.

Planet-A. The tenth scientific satellite is to be launched into heliocentric orbit during FY 1984 to observe the interplanetary plasma in the inner regions of the Earth's orbit as well as to take close-up ultra-violet images of Halley's Comet during March 1986. The cylindrical satellite will weigh about 125 kg.



The LE5 Lox/liquid hydrogen engine will be used on the second stage of the ETV and H launchers.

NASDA

Astro-C. The eleventh scientific satellite will be built to succeed Astro-B and will conduct more comprehensive studies in X-ray astronomy. The 400 kg satellite will be launched into a 500 km circular orbit during FY 1985. With its increased size and weight over Astro-B (although the box and four paddle shape will remain), the satellite will be able to observe more precisely the behaviour of celestial X-ray sources.

Sepac: The Space Experiments with Particle Accelerators experiment, developed by ISAS and NASA's MSFC in association with the South-west Research Institute in Texas, will carry out controlled active experiments on plasma by disturbing it with the injection of charged particles, accelerated by electron and ion beam accelerators, to generate aurora-like luminescences, waves, etc.

The six applications satellites planned for launch by NASDA are:

ETS-3. The third Engineering Test Satellite is intended to carry out tests on three-axis attitude control, solar paddles and active thermal control in order to enhance the development of technology common to satellites requiring a large amount of electrical power. Launch was planned on the final N-1 (number 7) in early 1982. The 385 kg satellite should be put into a 1000 km circular orbit inclined at 45 degrees.

CS-2a and CS-2b. The Communications Satellites 2a and 2b are comparable to the *Sakura* Medium Capacity Communications Satellite launched in December 1977 which conducted experiments in satellite communications using quasi-millimeter waves (the first utilisation of these frequencies in satellite communications). The new satellites are to be launched into geostationary orbits at 130 degrees and 135 degrees E longitude in early 1983 and mid 1983. CS-2b will act as an on orbit spare. Principal objectives for the cylindrical 350 kg satellites are to offer domestic communications services for public and official purposes and to develop technology for communications satellites of the future.

BS-2a and *BS-2b*. Broadcasting Satellites 2a and 2b are comparable to the *Yuri* Medium Scale Broadcasting Satellite for Experimental Purposes (BSE) which was launched in April 1978. This was a step towards a large scale broadcasting satellite system able to respond to growing demands of TV broadcasting and able to beam signals to individual small TV receiver dish antennae. *Yuri*, with three transponders, operated for 27 months, giving excellent results. It is planned to launch BS-2a and BS-2b (the on-orbit spare) into geostationary orbit at 110 degrees E Longitude in early 1984 and mid-1985, respectively. The satellites, carrying equipment for the relay of two colour TV channels, are expected to eliminate poor TV reception areas and further develop direct satellite broadcasting techniques. The box-shaped satellites, with two solar paddles will weight about 350 kg each.

MOS-1. The Marine Observation Satellite, weighing about 750 kg, will be launched by a two-stage N-2 into a 99 degrees inclination Sun-synchronous orbit with a height of 909 km in early 1985. It will carry four instruments to study land and ocean surfaces. The most important experiment will use a multispectral Electronic Self-Scanning Radiometer to image the Earth's surface at 50 m resolution using electronic charged coupled devices (CCD), the first time that such devices will have been carried on an Earth observation satellite. Other experiments involve a Microwave Scanning Radiometer, to observe sea-surface temperature and water vapour content of the atmosphere; a Visible and Thermal Infrared Radiometer and a Data Collection System to relay data from remote platforms collecting data on land and at sea. The box-shaped satellite has one large solar paddle.

Future Plans

ISAS is currently investigating a Mu-3S mod. 2 variant which, if funded, will launch a test satellite late in FY 1986. The first science payload for the new rocket would be the Exos-D aeronomy satellite. Other projects studied by ISAS, but not approved, include an infrared telescope for use on the US shuttle, an ultraviolet survey satellite, an X-ray telescope satellite, a high energy solar physics satellite and two probes to Venus. Many of these projects may never be funded.

NASDA has many satellites under study, to be launched on the H-1A. These include an Earth resources satellite, ERS-1, carrying a synthetic aperture radar and other Earth sensing instruments. If funded, it will move Japan away from dependence on the US Landsat system. Planned orbit for the satellite is 350 km, inclination 98 degrees Sun-synchronous. Other satellites studied include an electromagnetic environment observation satellite, a geodetic satellite, more geostationary weather satellites (including a spare, GMS-3, to be available for launch after FY 1984), and large capacity experimental comsats.

Acknowledgements

The writer would like to thank the International Affairs Department of the National Space Development Agency of Japan for information supplied in the preparation of this article. Major reference sources included *Space in Japan 1981–82*.

THE MEDICAL AND PUBLIC HEALTH CHALLENGE OF SPACE

Oliver H. Loyd and Kennedy J. O'Brien*

The development of space as a new frontier promises to dominate the next century. Clinical medicine and public health will not only benefit immensely but will be called upon to actively support this development. We expect the field of Aerospace Medicine to pioneer this movement. Currently, the seats of Aviation and Space Medicine rest for the most part within the governmental and military domains. This has perhaps been appropriate for the past. However, as Space Medicine develops, its home should be in academic institutions such as schools of Medicine and Public Health.

Introduction

Pilatre de Rozier, a surgeon, and the Marquis d'Arlandes became the first men in history to fly. On 21 November 1783, they took off from Bois de Boulogne in a Montgolfiere-type balloon for a flight that lasted 25 minutes. After they landed, they folded the balloon and went home. In spite of the excitement of floating free high above fields and woods, the world's first flying surgeon preserved his scientific detachment and noted that flying has no unfavourable effects on the physical system [1].

The historical advances of aerospace flight have been paralleled by similar timely advances in the biomedical sciences. Doctors and medical researchers have made the crucial contributions which render high altitude flight safe and commonplace for millions of people. Indeed, one would not be overstating the fact that in less than 30 years, bioastronautics has been instrumental in converting space travel from science fiction to science fact.

Now modern Man is on the verge of the second phase of this new era; the Space Shuttle [2-4] promises to be the gateway to a new "High Frontier" [5] and the workhorse for its economic and social development. Considerable thought and planning has blossomed into many extensive and detailed proposals for both commercial industry and space colony development [6-14]. The potential returns are staggering.

We must now begin to consider the roles and functions of medicine in this development of space, the potential for biomedical research and the applications which are waiting to be explored. There are innumerable questions to be asked and answered about the extreme environment and unlimited returns in knowledge and technical spin-offs for the doctor and his patient [15-18].

Benefits of Aerospace Developments

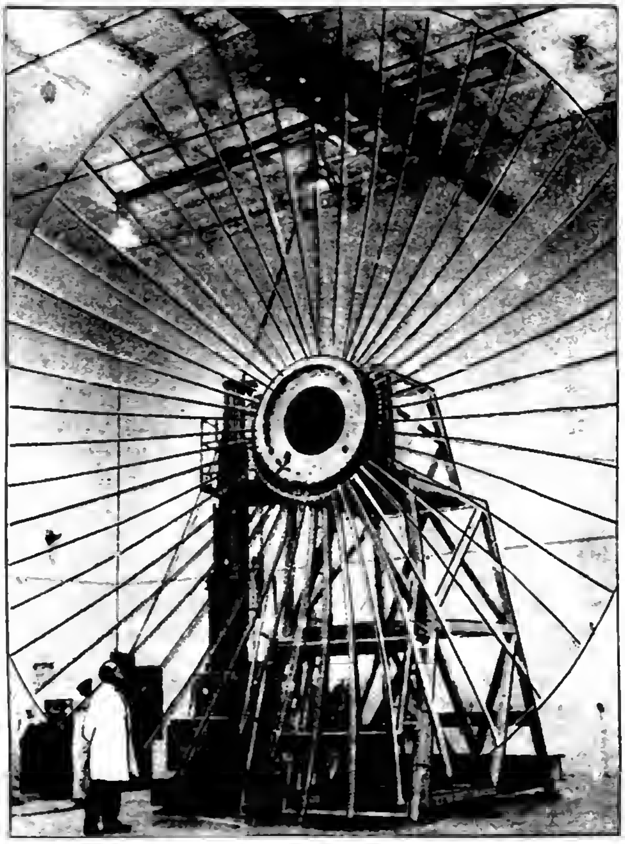
There are already substantial returns from space medicine which many people now seem to take for granted. The remote date acquisition, monitoring and interpretation of physiological processes during flight have generated many technical improvements in the quality and quantity of health care. Witness the cardiac pacemaker, the incubator for premature babies, the transmission of EKG's in a speeding ambulance to a hospital miles away, the TV diagnosis of genetic effects in the unborn child, and the new laboratory analysis techniques. The list goes on and on.

Public health and safety have also been immeasurably improved; satellites monitor agricultural growth, ecological changes, weather, and air and sea pollution, to name but a few. Space research and technology have aided communication between doctors in hospitals continents apart, and in the health education of remote isolated village populations. Laser surgical techniques, computer imaging, miniaturisation of biomedical sensors are also spin-offs of space biomedical research. In fact, the development of life support systems for Man in space has generated immense health returns for Man on Earth; with the advent of the Space Shuttle, we now realise that we have only scratched the surface!

Future Perspectives

It is projected that the commercialisation of space is within our grasp and that large populations will be living and working there within our grandchildren's lifetimes. Research is now coming to grips with the problems involved in extended living in space [19-30] because doctors and researchers know that their contributions will be essential and decisive in making this happen. Because the space environment has not yet been duplicated on Earth, the medical mind is challenged for solutions to the health and safety problems that must be overcome, such as radiation, extremes of heat and cold, total vacuum and weightlessness. Medical researchers have already proven, in less than 30 years, that these problems are not insurmountable.

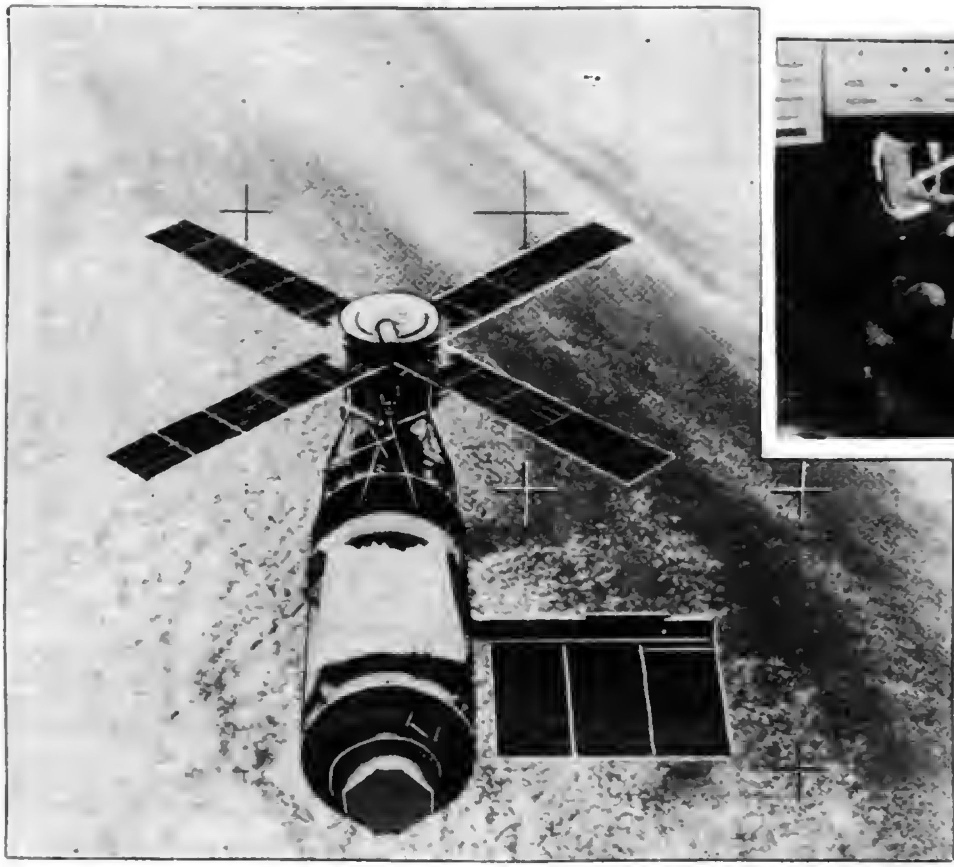
Commercialisation will bring vast economic and industrial benefits with new and exotic processes and products which could never have been made on Earth. However, it will also generate new and unusual occupational health and safety problems as yet unknown to medicine. Large populations, living in enclosed artificial environments, will have to depend



The ATS-6 communications satellite, with its 30 ft diameter antenna, demonstrated the feasibility of using such craft for connecting patients in remote areas with doctors in medical centres.

NASA

* *Department of Environmental Health Sciences, School of Hygiene and Public Health, The Johns Hopkins Medical Institutions, USA.*



Skylab provided American doctors with their first data on long-term (months) effects of weightlessness. *Inset*: Skylab astronaut Conrad in the Lower Body Negative Pressure experiment, designed to provide information on cariovascular adaptation.

NASA

on delicate, highly attuned ecosystems management. Relative isolation for long periods may have very interesting social and medical sequelae. Changes in herd immunity and infectious diseases, and gene pooling, are but a few of the areas which may have broader consequences and applications. This is to say nothing of the behavioural and psychological aspects of health, stress and working in the new environment. Of course, the pioneers will also bring their usual ills and maladies with them and develop totally new ones which will need to be described and managed. Doctors and medical researchers will definitely be among those living and working in space, wherever patients are in need of health care.

Roles of Health Institutions

The space colony or factory would be incomplete without readily available medical care. Though it is obviously impossible to predict exactly when it will occur, we suggest that medical institutions will be an integral part of these colonies. They will contain all of the specialities now available on Earth and probably some entirely new ones. They will operate much as they do now, but with larger research components. It would not be unreasonable to suggest that residents might spend one or more of their training rotations in such an institution or that Ph.D. candidates would pursue their research projects in its laboratories. It will be from this new base, hundreds of miles up in space, that medicine and the life sciences will enter a new renaissance. Unencumbered by gravity and surrounded by the ultimate vacuum, new drugs, new medical and surgical techniques, and new research discoveries will occur. The cure and prevention of many present diseases, including cancer, may be waiting to be discovered in orbit.

As commercial industry and construction gains a foothold in space, it is most likely that medical institutions will contract to provide the primary occupational and environmental health care for the workers and their families. This is based on the impression that as more private corporate involvement occurs, governmental agencies will revert to a secondary supporting role after the commercial exploitation of space begins. This new industrial revolution will provide occupational medicine with a new and exciting dimension.

Transitions Ahead

We are at the beginning of a transition period in space exploration. It may occur rapidly or slowly depending on the public interest, the need for new economical sources of energy [31-34], the possibility of war, and other variables, but expansion into space will be inevitable. We strongly believe that aerospace medicine will continue to be the basis for the future development of medical care in this area, though the speciality may very well become known by a new label: environmental medicine.

To draw on a historical perspective, it is suggested that practitioners of aerospace medicine already have the skills and temperament to carry medicine through the transition period as illustrated by their key role in the development of aviation. However, an expanded role for these environmental medical specialists is anticipated to occur over the next 30 to 50 years. This role will encompass the principles of health, primary care and occupational medicine – not unlike his present-day terrestrial colleague; only the working environment will change. It would be presumptuous and incorrect to say that it will become the preserve of aerospace medicine alone. Rather, this specialty is seen as being mainly the initiator and coordinator during the transition period.

This transition period can be broken down into three phases with regard to aerospace medicine. We are presently in the first phase, in which the specialty currently provides the primary medical support for the space effort. As the industrialisation of space and the development of extraterrestial sources

of energy begin within the next three decades, environmental health and hygiene inputs will be required in the creation of healthy workplaces and laboratories in orbit. Because of the understanding that the aerospace doctor has of extreme environments, it would only be logical to assume that he will provide the primary care for some period of time.

In the second phase of the transition period, the space communities will probably be carrying out a large number of research projects coordinated with the traditional medical research centres on Earth. It will also become necessary, as the colonial population starts to grow, to consider the effects of the exploitation of space on populations, not only on space colonies, but also on the mother population on Earth. Therefore, it is most likely to be during this second phase in the transition that some academic hospitals, commercial pharmaceutical companies and the like will put together and maintain their own research laboratories in space. It will be from this initial base that large-scale medical care facilities will likely expand. It will also be here that questions such as "How will we put on casts in zero gravity, perform operations in space, do autopsies, investigate accidents, and deliver babies?" will begin to be answered.

In the third phase, we see a declining role for the aerospace doctor. Indeed, new specialties may evolve and traditional specialties expand to fulfil new needs. All throughout the transition period, the role of nurses, laboratory technicians and other medical support personnel will become increasingly important as small biomedical facilities grow to become space hospitals.

Now is the time to consider the present and future technology transfer possibilities for both public and individual health. We must now begin to study the health problems relating to the development of solar energy in space, the effects of microwave transmission on populations, as well as the benefits which will accrue.

Now is the time for the aerospace medical profession to provide more training and educational resources necessary to prepare for its expanding role. In addition, schools of medicine, university academic centres and schools of public health must begin to plan their participation in the development in space. In particular, they should begin to examine this new field for its potential benefit to public health and welfare in a truly global sense, and actively support and contribute to those aspects which can provide distinct improvements.

What has been described here is not science fiction; much of what we have said is already on the drawing board. Several medical institutions' acknowledged excellence in health care and research as well as their geographic locations make them prime contenders for an important role. The time is now ripe to begin serious examination and discussion of the opportunities open to medical institutions with the advent of the Space Shuttle.

Acknowledgement
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SPACELAB 2 TELESCOPE TESTED

A large infrared telescope cooling system destined for space aboard Spacelab 2 in 1984 has been undergoing thermal performance tests at NASA's Marshall Space Flight Center in Huntsville, Alabama. The cooling system is part of the Helium-Cooled Infrared Telescope Experiment.

The cooling system of the telescope must maintain the infrared detectors at a super-cold temperature in order for the instrument to work. "Since the telescope will be scanning newly-forming stars and other sources of infrared radiation, which is emitted from warm objects, we have to make sure that the instrument doesn't measure infrared from itself," said Co-Investigator Dr. Eugene Urban of Marshall's Space Sciences Laboratory. "So we have to keep parts of the telescope as cold as possible, about minus 450 °F."

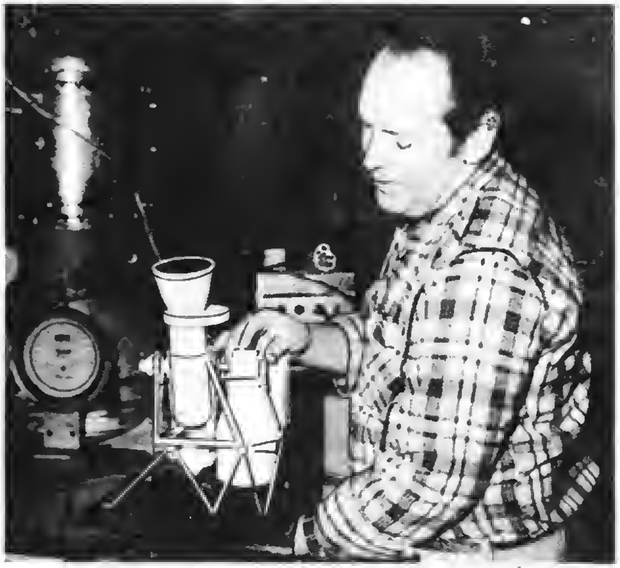
Liquid helium, the coolant used in the system, will be stored during the mission in a 250 litre dewar container. "We've sometimes compared the dewar to a thermos bottle," said Urban, "although it's far more sophisticated. It has vacuum jackets, insulation, thermal radiation shields and a highly complicated plumbing system."

Vaporised helium, drawn from the liquid in the dewar and nearly as cold as the liquid helium itself, will be circulated through various channels of the telescope to keep the instrument near absolute zero.

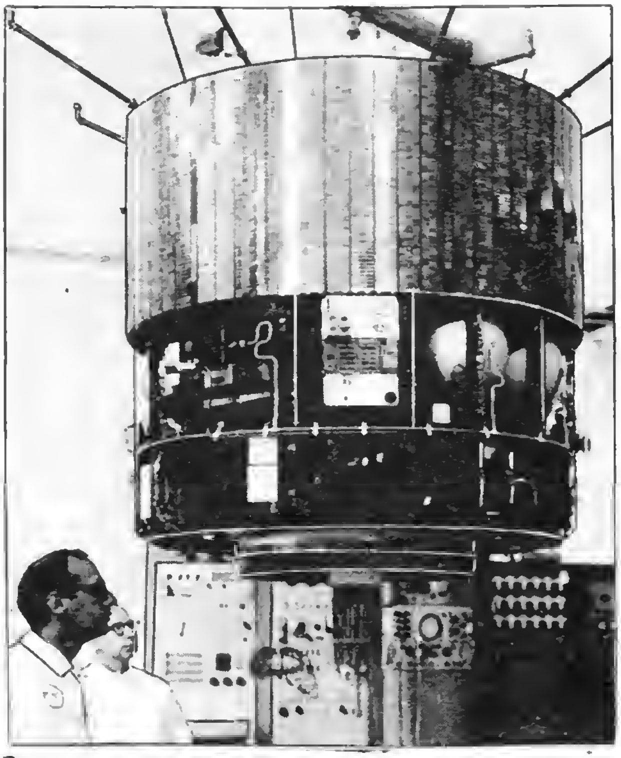
The mechanical and cooling systems of the experiment are under Marshall Center development, while the telescope itself is being designed by the University of Arizona under a joint effort agreement among Marshall, the University and the Smithsonian Astrophysical Observatory. The University of Alabama at Huntsville is assisting Marshall in the development of the dewar system.

Among the tests being performed at the Marshall Center is a measure of the flow rate of the helium as it boils off from the liquid (a determinant of thermal efficiency). Scientists are also measuring the temperatures of various components of the cooling system, to ensure that the super-cool conditions are evenly maintained.

"One of the objectives of these tests is to see how long the cooling system can store such a cold liquid," said Dr. Dan Ladner, a Space Sciences Laboratory physicist who assists Urban in the telescope experiment. "We want the cooling system to last for several weeks, because the dewar would be filled with liquid helium one or two weeks before the launch of Spacelab 2 and then undergo a mission of seven days."



A model of the Helium-cooled Infrared Telescope. A full size unit can be seen in the background.
NASA



One of the early technology-proving ATS satellites. See news story below.
NASA

ATS-1 REPOSITIONED

NASA has started to relocate the geosynchronous Applications Technology Satellite-1 (ATS-1) from its present position at 149 degrees west longitude to a new position at 162 degrees east longitude.

The old location required maximum thruster use to maintain orbital position. Relocating to 162 east longitude puts the satellite into a more stable position where the power from onboard thrusters for station-keeping is reduced substantially, extending the lifetime to beyond mid-1982.

This action will prolong the orbital station-keeping period to 1983 and reduce station-keeping activities to quarterly from bi-weekly. This new position also improves the satellite's "look angle" to more westerly islands in the Pacific Basin.

ATS-1 is the oldest synchronous communications satellite still in use. Present experiments include voice transmission among 11 Pacific island nations, the Trust Territory of the Pacific, Australia, New Zealand, Hawaii and California. Other experiments provide medical care communications for Alaska, technology transmissions between Japan and Australia, and coordination of oceanic research vessels in the Pacific and Gulf regions.

ATS-1 was launched on 7 December 1966, and has been a pioneer in the use of communications satellites for health services, education, public safety, emergency communications and mobile land and maritime applications.

The repositioning manoeuvre is expected to take about eight months to complete. Full communications with ATS-1 will be

maintained throughout with periodic adjustments of ground station antennaes to keep the satellite in view.

EUROPEAN LAUNCHER STUDY

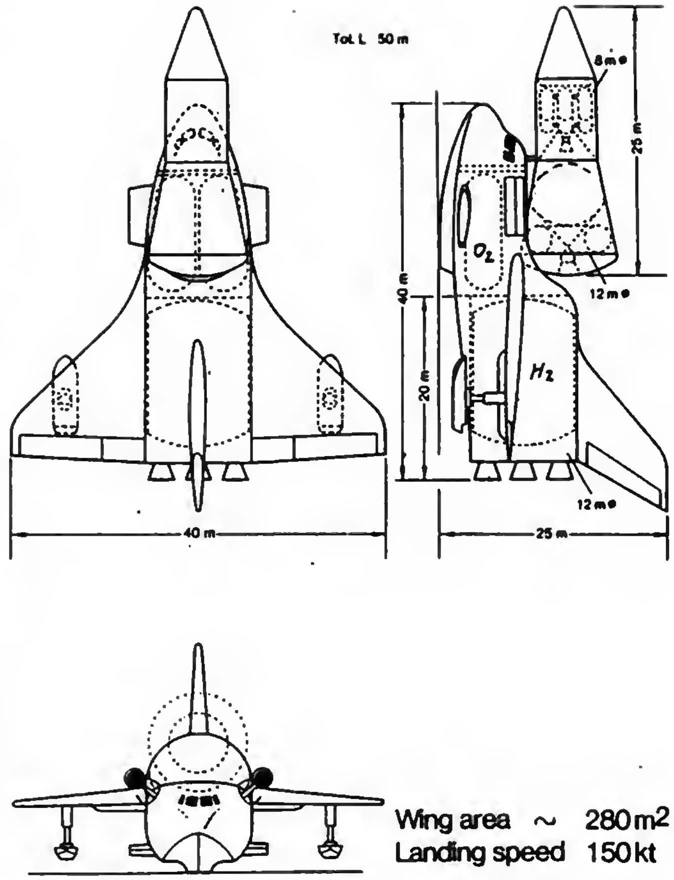
It is generally recognised that Europe's Ariane launcher will not be able to handle the space payload requirements of the late 1990's. Ariane 4 will be adequate until early that decade but frequent trips into geostationary orbit (for large communications platforms, and solar power satellites, for example) will need a much larger, more versatile type of launcher.

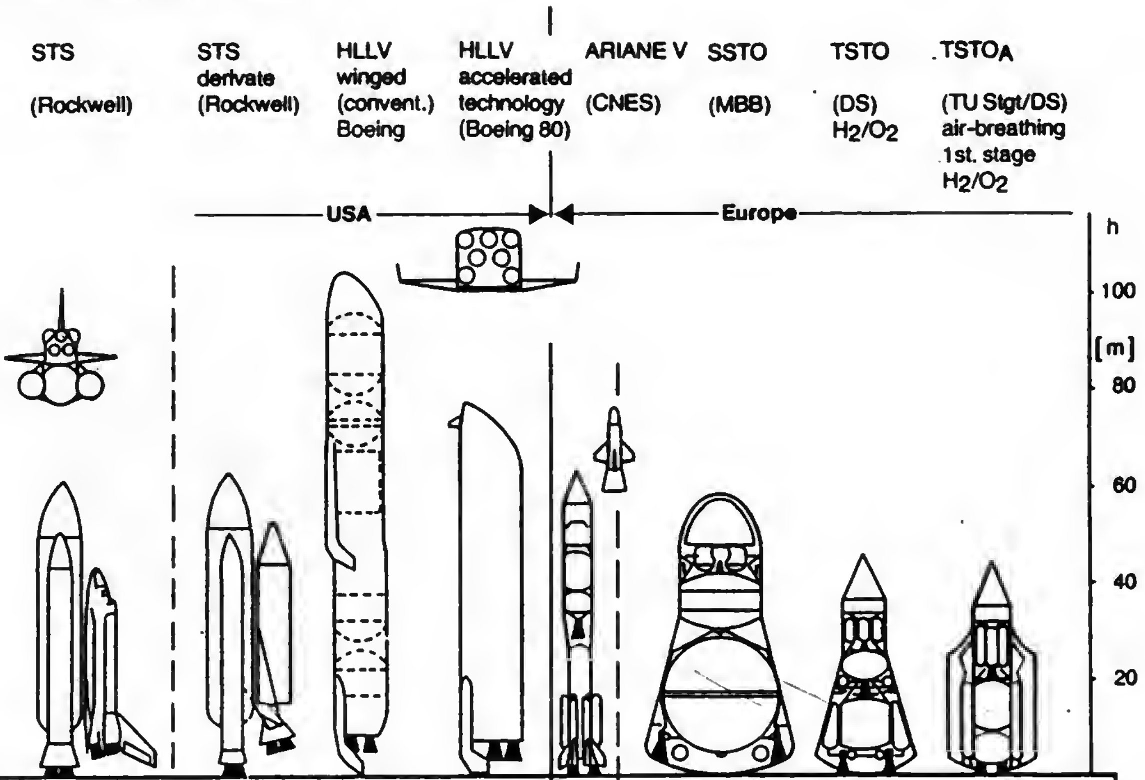
R.G. Reichert of Dornier presented the paper "Potential Long Range Trend in European Space Launcher Developments" at last September's IAF Congress in Rome. His study pointed out that, by the year 2000, Europe will need a launcher capable of taking 50 tonnes into low Earth orbit. The launcher should be fully reusable which, although resulting in high development costs, yields lower operating costs. An orbital transfer vehicle will also be necessary.

One vehicle studied is the "TSTO" - the Two-Stage to-Orbit ballistic vehicle powered by oxygen/hydrogen engines. With a lift-off mass of around 900 tonnes and a total height of 42 m, the launcher could handle a payload diameter of 8 m. The 17 m diameter first stage would return to Earth for ocean recovery and eventual reuse.

An alternative design would be to use an aerodynamic first stage, looking rather like a squat, present-day Shuttle Orbiter. Total lift-off weight would be about 1200 tonnes and the bulky liquid hydrogen (see diagram) would sit at the rear. Jet engines would assist in the runway landing.

Right: a Dornier shuttle study using an aerodynamic booster and more conventional upper stages. *Below*: Launch vehicle proposals to follow on from the present Shuttle. W_0LEO is the mass into Low Earth Orbit, GLOW in Gross Lift weight (both in tonnes).





W_0 LEO [t]	30	60	120 (420)	225	10	60	60	60
GLOW [t]	2000	3000	4000 (11000)	1600	330	2500	900	600

EARTH-SPACE STUDY SCIENCE TEAM

The NASA Office of Space Science and Applications has selected the scientific team to work on the science definition phase for the Origins of Plasma in Earth's Neighbourhood (OPEN) mission.

These scientists will begin to define the instrument packages which will fly aboard the four-spacecraft mission proposed for late this decade. The mission, although not currently authorised, is expected to provide detailed information concerning the Sun's energy and its transfer from the solar wind through the Earth's magnetosphere and down through the ionosphere. The mission involves four spacecraft, one sampling the incoming solar wind and three measuring key areas of the Earth's magnetosphere (the polar regions for energy deposition; near-Earth equatorial region for energy storage and transfer; and the distant magnetotail region for storage and transfer).

Because this is a sophisticated mission, definition studies for the intrumentation and mission plans must begin now if it is to be ready for flight in the late 1980's.

COSMONAUT KILLED

One of the two Vietnamese cosmonauts who trained for the joint Intercosmos manned flights was killed in an air crash last year, writes B. Vis. The East German newspaper *Neues Deutschland* of 30 September 1981 reported that Hanoi had announced the death of Bui Thanh Liem, who acted as back-up to the Soyuz 37 cosmonaut Pham Tuan.

UPPER ATMOSPHERE STUDIES

NASA's Office of Space and Terrestrial Applications has selected nine experimental and 10 theoretical teams for participation in the proposed Upper Atmosphere Research Satellites (UARS) programme.

The UARS programme is designed to obtain data on the energy input, chemical composition and dynamics of the Earth's stratosphere and mesosphere in order to determine the chemical and dynamical state of the upper atmosphere and its susceptibility to change. Interest in stratospheric chemistry has been heightened over the last decade by growing awareness of the potential for reductions in stratospheric ozone caused by emissions from high flying aircraft and by chlorofluorocarbons from aerosol spray cans, refrigeration, air conditioning and foam blowing operations. (See "The Solar Mesosphere Explorer" in *Spaceflight*, January 1982, pp. 24-25).

The experimental teams will develop instruments to make direct measurements of upper atmospheric winds, measurements of solar ultraviolet irradiance, energetic particle interactions with the upper atmosphere and densities of critical chemical species as a function of altitude. The theoretical teams will develop and apply models of the upper atmosphere which, when combined with the new data, should significantly increase our understanding of upper atmospheric chemistry and dynamics and improve the capability to assess the impact of Man's activities on the delicate chemical processes in the stratosphere.

CHANGE IN VENERA/HALLEY MISSION

CNES, the French space agency, has announced changes to the 1984 Soviet Venera/Halley's Comet probe which was scheduled to drop balloons into the upper layers of the Venerian atmosphere, writes Neville Kidger. The French say that the balloons, which were to have been made in France, have been dropped from the revised plan in favour of a craft which will land on the night side of the planet.

The project, now named VEGA, also envisages observations of Halley's Comet in March 1986 from the carrier bus spacecraft after it has carried out its ferry role for the lander probe. The French will participate in eight experiments on the flight, four each on the lander and the bus. The maximum weight allowed to the French for scientific payload is 50 kg.

The experiments consist of (on the lander): mass spectrometer, aerosol collector, ultraviolet spectrophotometer and equipment for measurements of pressure and temperature during the descent. On the comet observation bus the French are to participate in the TV imaging experiment (which will use a French-built telescope), infrared spectrometer, three-channel spectrometer and plasma wave analyser.

French-built Signe 2MS3 gamma-ray burst detectors were carried to Venus on the Venera 13 and 14 probes. Another French payload, to be flown aboard a Soviet spacecraft in 1984, is a gamma ray telescope called Gamma 1.

US MILITARY SPACE SPENDING

United States military space spending is expected to double in the next seven years, growing from $477 million in FY1981 to $959 million by FY1987 (in 1980 dollars).

Funding will increase at an average annual rate of 13 per cent, the marketing research firm Frost & Sullivan predicts in its study, "The Space Defense Market In The U.S.".

Over the past ten years, space has become of increasing importance in military planning. The US is currently spending about $4000 million per year on the development and procurement of its military space systems.

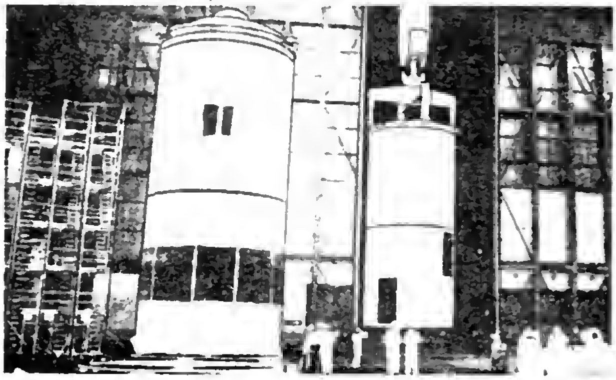
There are some indications of a shift in US military space policy. There appears to be movement away from developing space weapons purely for a retaliatory capability towards as offensive role. In addition, there has been increasing consideration of the potential of space-based weapons as a defence against ballistic missile attack.

Of the $959 million projected for military space systems in FY1987, fully $799 million will go to weapons systems. These include: high-energy lasers (FY1987 spending of $451 million); particle beam weapons ($48 million in FY1987); and space weapons systems ($300 million in FY1987).

European Spacelab 1 payload specialists Wubbo Ockels (left) and Ulf Merbold in training at the Marshall Space Flight Center in Alabama for the September 1983 mission. Only one will fly.

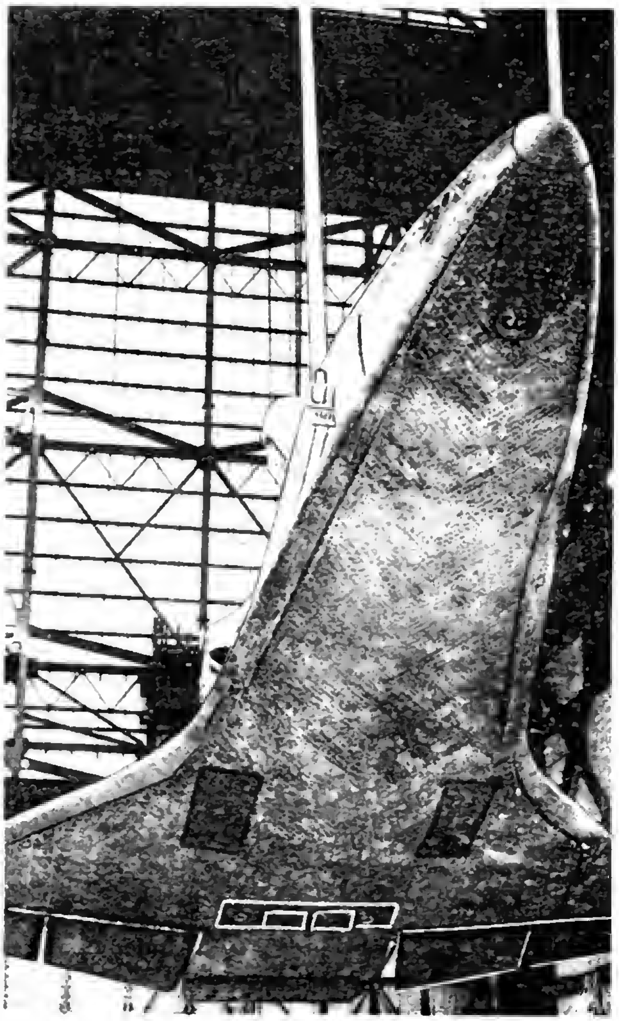
NASA

PREPARING *COLUMBIA* FOR MISSION 3

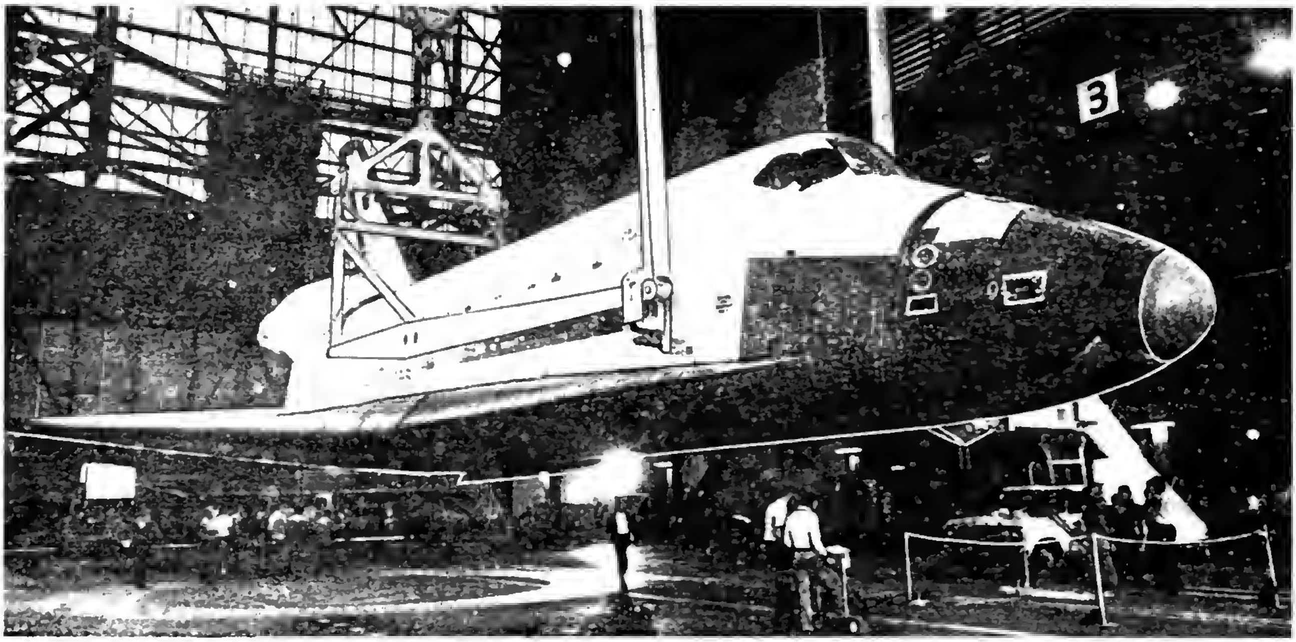


Solid Rocket Booster segments being prepared for stacking.

Removing the fuel cell that forced the second mission to be cut short. Technicians stand in *Columbia*'s open cargo bay with the airlock of the pressurized crew compartment at left.

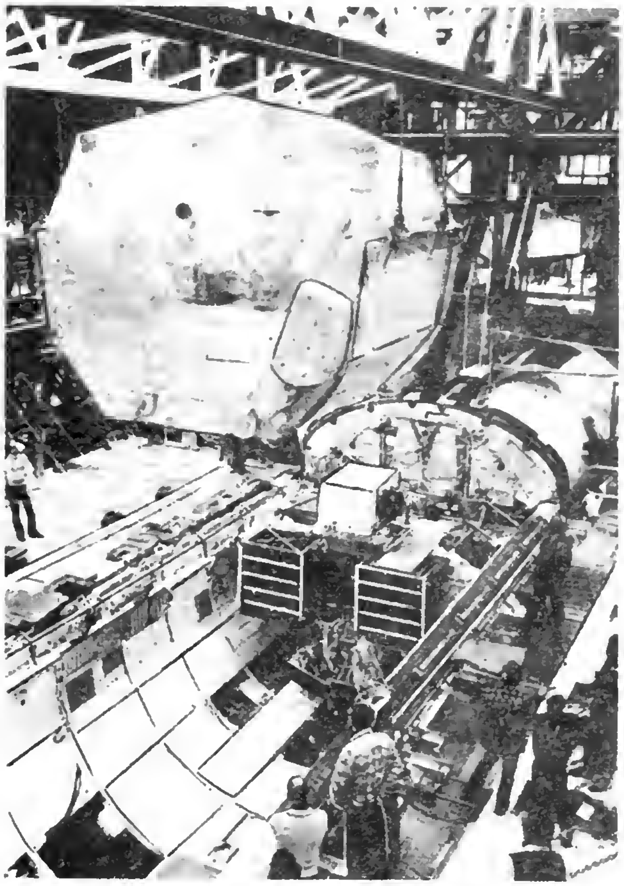


The underside of *Columbia*. Note the External Tank connections at the lower end and the darker areas of the undercarriage doors.

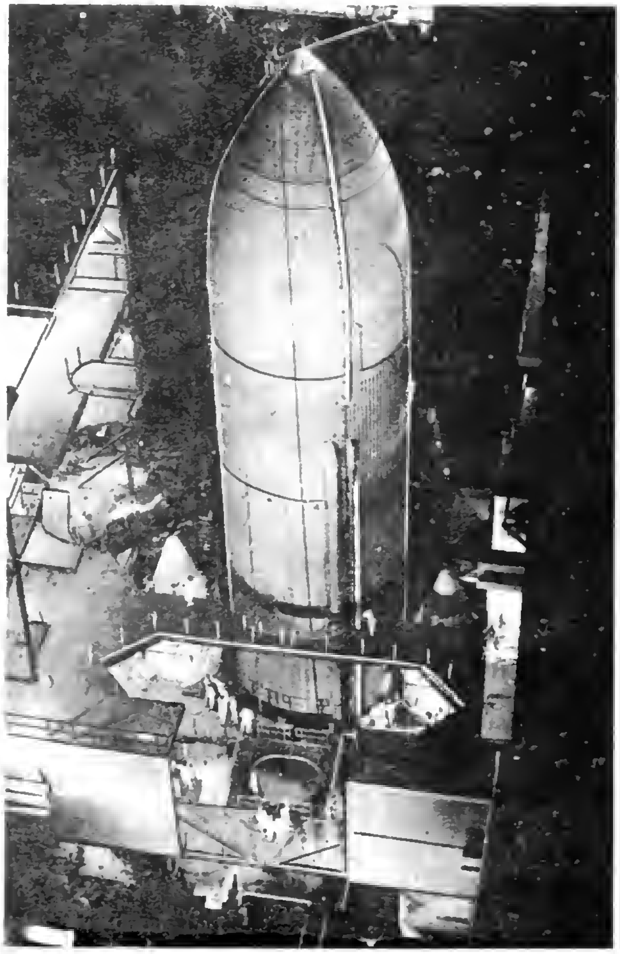


With landing gear retracted, Orbiter *Columbia* is lifted clear of the floor of the Vehicle Assembly Building for positioning on the mobile launcher.

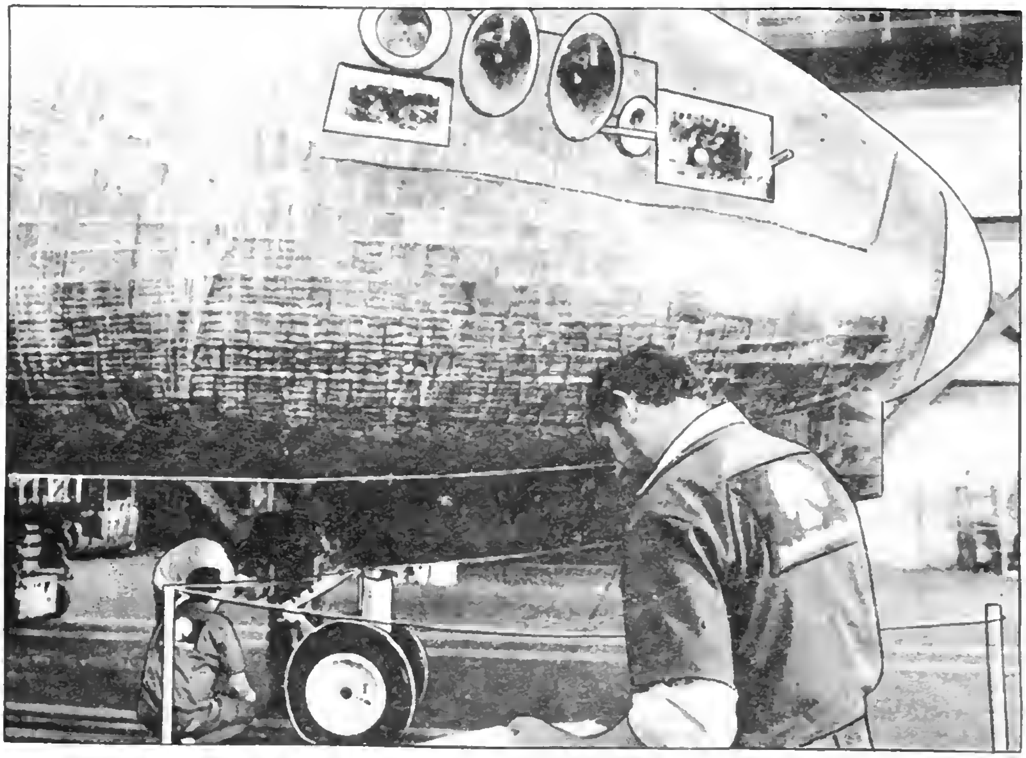
All Shuttle photographs courtesy of NASA



The Space Sciences pallet (OSS-1) is lowered into *Columbia*'s cargo bay while the Orbiter is in its Processing Facility. OSS-1 was designed to study the electromagnetic environment of the orbiting craft, the optical effects of any spacecraft-induced contamination, solar flares, ultra-violet radiation, plant growth in weightlessness and temperatures in the experiments area.



The External Tank is lowered into position for mating with its Solid Rocket Boosters. Note the access platform (in front of the Tank) designed to fit around the Orbiter.



The effects of two re-entries can be seen on the thermal tiles of *Columbia*'s nose.

THE ASTRONAUTS OF STS-3

Commander of the third Shuttle orbital mission, Jack Lousma (left) and his pilot, Gordon Fullerton.
NASA

Jack Robert Lousma

Colonel Jack R. Lousma, Commander of STS-3, was born on 26 February 1936 in Grand Rapids, Michigan. Educated in schools in Michigan, Lousma gained a Bachelor of Science Degree in Aeronautical Engineering from the University of Michigan in 1959. He became a Marine Corps officer in 1959 and received his wings in 1960 after completion of training at the US Naval Air Training Command. Assigned to VMA-224, 2nd Marine Air Wing, he served as an attack pilot, later transfering to VMA-224, 1st Marine Air Wing, in Japan. In 1965 he received an Aeronautical Engineering degree from the U.S. Naval Postgraduate School. Prior to entry to the astronaut programme, Lousma was assigned as a reconnaissance pilot with VMCJ-2, 2nd Marine Air Wing, Cherry Point, North Carolina. He has logged over 5500 hours flying time in his career.

As one of the nineteen Group 5 astronauts selected by NASA in 1966, Lousma began training for the Apollo programme.

His first assignment was as a replacement on the Apollo 9 Support crew (Haise had moved to backup Lunar Module Pilot on Apollo 8). His assignments were then: CapCom Apollo 10; CapCom Apollo 13; named Pilot second manned Skylab mission January 1972, flew mission 28 July to 28 September 1973, set World endurance record for manned spaceflight at 1427 hrs 9 mins (59 days). He also logged 11 hrs 2 mins in two periods of EVA outside the Skylab workshop. He was named backup Docking Module Pilot for the Apollo Soyuz Test Project, and following completion of his Skylab duties he assumed full training for the mission, making several trips to the USSR as part of the training programme.

Following ASTP he was assigned to the Shuttle programme and took an active part in the development of the Shuttle system. He was named as Pilot of the third STS crew on 17 March 1978, with Fred Haise as his Commander. When Haise left NASA on 29 June 1979, he continued his training for the STS flights, and was subsequently named as Commander of STS 3 with Gordon Fullerton as his pilot.

Charles Gordon Fullerton

Pilot for the third manned Shuttle mission was Charles "Gordo" Fullerton, a Colonel in the Air Force. Born on 11 October 1936 in Rochester, New York, he was educated in Portland, Oregon before entering the Californian Institute of Technology. He graduated in 1957 with a bachelor of science degree, and then in 1958 was awarded a master of science degree (both in Mechanical Engineering). He subsequently worked as a mechanical design engineer for the Hughes Aircraft Company. He joined the Air Force in July 1958, receiving flight training at Brainbridge AFB in Georgia, and Webb AFB in Texas. He then undertook F-86 fighter interceptor training at Perrin AFB in Texas (September 1959–May 1960); from May to December 1960 he was assigned at McConnell AFB in Kansas for B-47 combat crew training, subsequently serving as a B-47 bomber pilot with the Strategic Air Command's 303rd Bomb Wing at Davis Monthan AFB in Arizona. He graduated from the USAF's Aerospace Research Pilot School at Edwards AFB in California in May 1965 and was assigned to the Aeronautical Systems Division at Wright-Patterson AFB in Ohio, serving as a test pilot for bomber operations division. His selection for the Manned Orbiting Laboratory Programme came on 17 June 1966 (Group 2), serving in the capacity of research pilot for three years until MOL's cancellation in June 1969. He then transferred to NASA in August 1969 (Group 7).

Fullerton entered the Apollo programme as a Support crew member for Apollo 14 and served as shift CapCom for Apollos 14–17. He was also Support crew member for Apollo 17. Following this period he was assigned to the Shuttle programme and undertook work on the mission recovery phase. On 24 February 1976, he was named as Pilot of the first ALT crew, flying the first (18 June) and third (26 July) manned captive flights, and the first (12 August), third (23 September) and fifth (26 October) free flights during 1977. He was named as Pilot of the fourth OFT crew on 17 March 1978 but when Fred Haise left NASA in June 1979, Fullerton moved to the Pilot's position on STS-3.

D. J. SHAYLER

GERMAN X-RAY SATELLITE

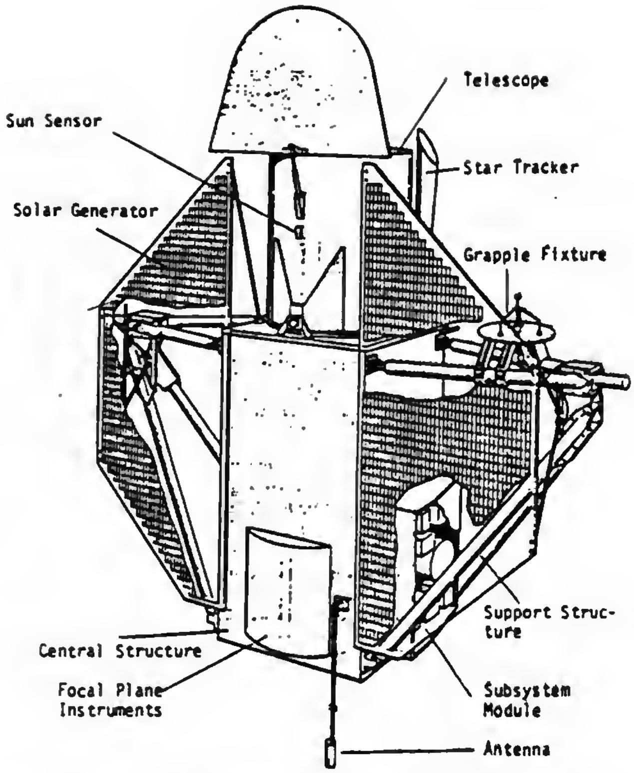
West Germany is developing a 2 tonne X-ray observation satellite which, when launched, will become that nation's fifth scientific satellite, writes Neville Kidger.

The Dornier-built X-ray observation satellite (Röntgensatellit) will carry an 80 cm diameter telescope, weighing about 1300 kg, which should allow the recording of the location, intensity and spectra of celestial X-ray sources between 0.12 and 2 keV. Pointing accuracy should be 1 arcminute.

The three-axis stabilised satellite will have two distinct pointing modes (whole sky survey and discrete source pointing) which should allow for continuous mapping and for prolonged (typically 3 hours) observations of discrete sources. The planned mission duration of one year should allow two all-sky surveys.

In addition to the German instrument, developed by the Max-Plank-Institut, the satellite may also house a wide-field soft X-ray camera, from the University of Leicester, operating in the 0.25 to 0.05 KeV energy range.

The launch of Röntgensatellit is planned for early 1986. The satellite will be placed by the Space Shuttle into a 430 km circular orbit included at 56°.



The German "Rontgensatellit" X-ray astronomical observatory.
MBB

SPACE VEHICLE

The cover of the March *Spaceflight* carried a picture of a manned space vehicle for the late 1980's studied by Grumman Aerospace for missions to high Earth orbits. This was the subject of a paper ("Manned Orbit Transfer Vehicles and Their Missions", by R.E. Boyland and R.L. Kline) presented at the 32nd IAF Congress in Rome. These craft - MOTV - would be launched in sections in Multiple Shuttle flights to low Earth orbit where the propellant drop tanks (the only expendable units) would be attached to the crew compartment and two-engine propulsion section.

The 2-man MOTV could then go on any onc of a variety of missions, such as transferring new men to space construction bases, servicing satellites or clearing debris away from much-used orbits. One of the most important would be servicing communications satellites in geostationary orbit, using replacement modules stored on the outside of the MOTV and manipulators at the forward end. An MOTV of about 90,500 kg (of which more than 80 per cent would be propellant) would have to be assembled in low Earth orbit for this type of mission.

The craft could be left in space between missions, being brought back to Earth only for major overhauls.

MEDUSA'S RESULTS

The Soviet Union has published results of the Medusa experiment conducted on the Salyut 6 space station, writes Neville Kidger. The results, reported in *Soviet Weekly*, hint at the possibility that life could have originated in space.

Although cassettes of the experiment, exposed both outside and inside the station during the period 29 September 1977–29 July 1978, were returned to Earth late in 1978 the results have taken some time to interpret at the Soviet Institute of Cytology.

In the experiment, two sets of containers holding components of nucleic acids, one open to the space environment and one closed, were mounted on the skin of the station's forward transfer compartment, while a third was carried inside the station as a control. Analysis revealed that substances similar to nucleosides, the sub-unit of nucleic acids, were formed in the exposed containers, but not in the control. In the closed container, shielded from ultraviolet radiation, the yield of the nucleosides was only 50% of that from the exposed container. The Soviet articles says this is a clear indication that the Sun is the main "giver" of life as far as the Earth is concerned.

The experiment, while showing that elements of biologically active substances are formed in space, does not prove that life originated from space - according to V. Kuzicheva, a senior research worker - but it illustrates the possibility. Life certainly needed Earth as a nursery for its development and it seems clear that life could have originated in other solar systems with conditions similar to our own, the article concludes.

MICROGRAVITY PROGRAMME

On 15 January the ESA Microgravity Programme formally began. In May 1981, the Agency's Member States agreed that such a programme should be carried out on an optional basis within the ESA framework. It then took some months to finalise the programme content to the satisfaction of all potential participants and within the financial limits they had laid down.

The proposals can be divided into two main areas, namely, life sciences, in which researchers can study the effects of greatly reduced gravitational forces on living organisms (from the most simple cells to the most highly developed, including Man himself), and material sciences in which the effects of microgravity conditions on the behaviour of fluids, crystal growth and metallurgical systems, can be studied.

In order to meet these objectives, it has been decided, initially, to concentrate on three main programme elements:

BIORACK
A multi-user experimental facility for investigations in the fields of cell and molecular biology in the weightless environment of Spacelab. Candidate experiments include studies of plants, insects, mammalian cells and bacteria. This facility is scheduled to fly for the first time on the German national Spacelab mission, D1.

FLUID PHYSICS MODULE
A multi-user experimental facility which will be flown on the first Spacelab mission in 1983. It is designed for the study of phenomena connected with the hydrodynamics of floating liquid zones. It is planned to improve the initial version of the Fluid Physics Module to take account of a change in user requirements due to a recent evolution in the microgravity sciences, and to fly this improved version on the German D1 mission.

Spacelab crew members will be heavily involved with work on both Biorack and the fluid physics module; they will not only insert and remove samples from both facilities but, particularly as far as the Fluid Physics Module is concerned, will also observe the behaviour of liquid zones through a viewport. The crew members will be in direct voice contact with experimenters on the ground and will thus be able to modify conditions as and when required.

SOUNDING ROCKETS
This consists of a series of experiments to be carried out using Sounding Rocket flights. The results obtained by the German and Swedish Sounding Rocket programmes clearly justify the use of sounding rockets for microgravity research. European experimenters will thus be given an opportunity to conduct experiments in solidification physics and fluid physics under easy-access conditions.

The ESA Microgravity Programme, as presently planned, is due to cover a period of four years at a total cost of 37.4 MAU (1 AU is equivalent to $1.065 at 1982 rates).

As in any new field, a considerable amount of basic research is necessary before the potential applications are known and become available. The growth of higher quality crystals for electronic components, improved metallurgical processes leading to better or new allows, a deeper understanding of the human body, and a better insight into biological processes such as plant growth, are but some of the avenues which will be explored in the coming years.

POLISH COSMONAUT MYSTERY

According to unofficial philatelic information from Poland, Zenon Jankowski was chosen by the Soviet Union to be the first Pole in space, writes L. Winick. The Polish government printed two stamps honouring Cosmonaut Jankowski as part of the 1978 Intercosmos programme.

The day before the flight, the Polish Philatelic Agency, Ars Polona, received word that M. Heraszewski was the first Polish cosmonaut; new stamps were printed. The incorrect stamps were destroyed, but some apparently escaped the shredding machines. Jankowski, officially, acted as back-up to Herazewski for the Soyuz 30 flight.

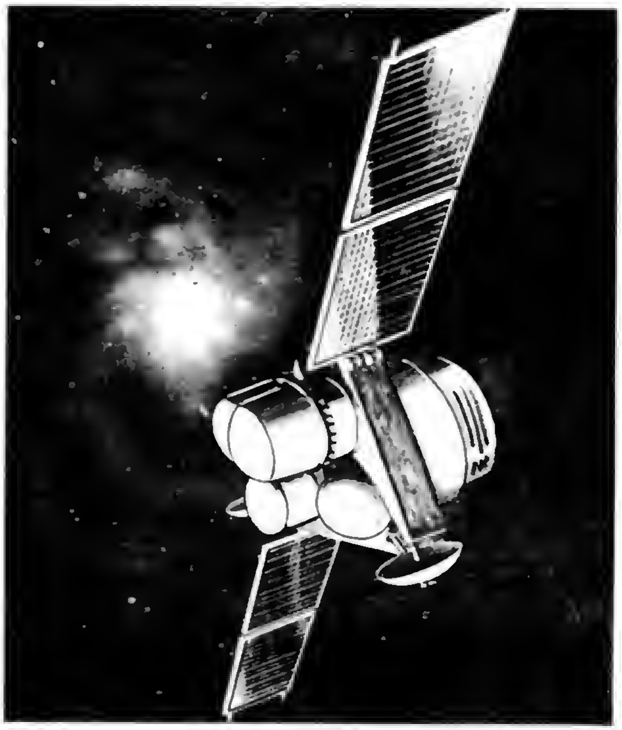
SHUTTLE INDIAN PAYLOAD

Indian physicists of the TIFR institute in Bombay have designed and are building a cosmic ray payload tentatively scheduled for launch aboard the Space Shuttle in April 1984. The apparatus, named "Anuradha", will first be tested by balloon flights up to high altitudes. The *Times of India* has noted that NASA supplied the launch opportunity free of charge, the only developing country to be so honoured.

MOON TREES

During the November 1969 flight of Apollo 12 to the Moon, NASA sent some 100 tree seeds with the astronauts to expose to the harsh conditions on the lunar surface, writes Dave Shayler. The experiment was to discover if the conditions had any lasting effects on plant growth. On return to Earth, the University of Florida planted a few of the seeds, under strict secrecy, in the campus grounds.

Twelve years later only one of these Moon trees survives, though its exact location is known only to NASA and a few college officials (to prevent souvenir hunters from taking saplings).



NASA's Gamma Ray Observatory is scheduled for a 1988 launch to investigate high energy processes in the Universe. *NASA*

IN THE PAST

25 Years Ago . . .
1 May 1957. Vanguard TV-1 was launched from Cape Canaveral. This second Vanguard test vehicle rose to a height of 121 miles.

20 Years Ago . . .
26 April 1962. Ranger 4 became the first US spacecraft to reach the lunar surface, although photography of the lunar surface was lost due to equipment failure.

15 Years Ago . . .
24 April 1967. Cosmonaut Vladimir Komarov loses his life during the parachute descent of Soyuz 1.

10 Years Ago . . .
16 April 1972. John Young, Charlie Duke and Tom Mattingly were launched aboard Apollo 16 bound for Man's fifth lunar landing on 21 April. Spending three days at Descartes base, Young and Duke continued the success of the Apollo series with 20 hr 14 min of lunar surface EVA.

5 Years Ago . . .
19 April 1977. First of two flight models of ESA's Meteosat (meteorological satellite) was delivered to the CNES space centre at Toulouse for mechanical and thermal testing.

D. J. SHAYLER

NEW SATCOM LAUNCHED

RCA's Satcom IV communications satellite was launched on 14 January by a Delta 3910 from Cape Canaveral into a transfer orbit prior to insertion into a geostationary path. At its position of 83 degrees west, Satcom IV will be used to distribute video programming to cable TV systems throughout the United States.

Satcoms I, II and IIIR were launched in 1975, 1976 and 1981, respectively, to provide coverage for all 50 States and Puerto Rico with TV, voice channels and high speed data transmission.

The satellite, measuring 37 ft across with solar panels extended, is designed to have a 10 year orbital lifetime.

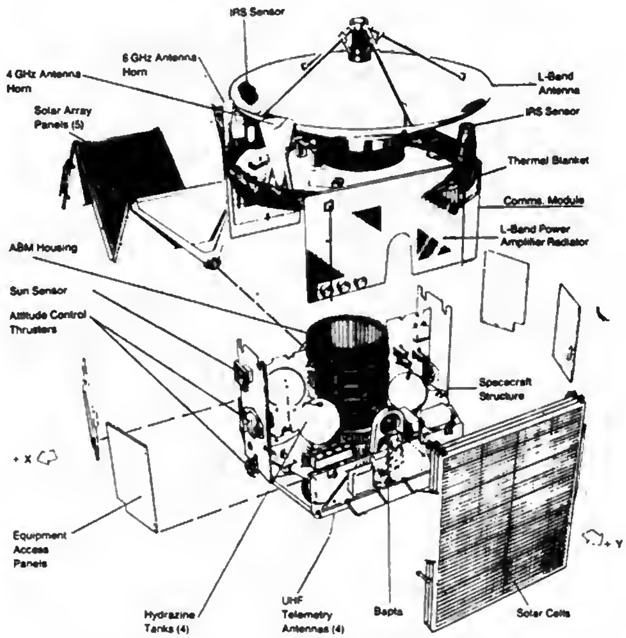
SATELLITE TV SERVICE

Satellite Television Corporation, a subsidiary of COMSAT, have announced plans to introduce a two channel pay-television service delivered via satellite to the northeastern US in late 1983.

STC President Irving Coldstein said, "The 1983 service is designed for multiple family dwellings. It is a forerunner to our direct-to-individual-home service targeted for introduction in late 1985 or early 1986."

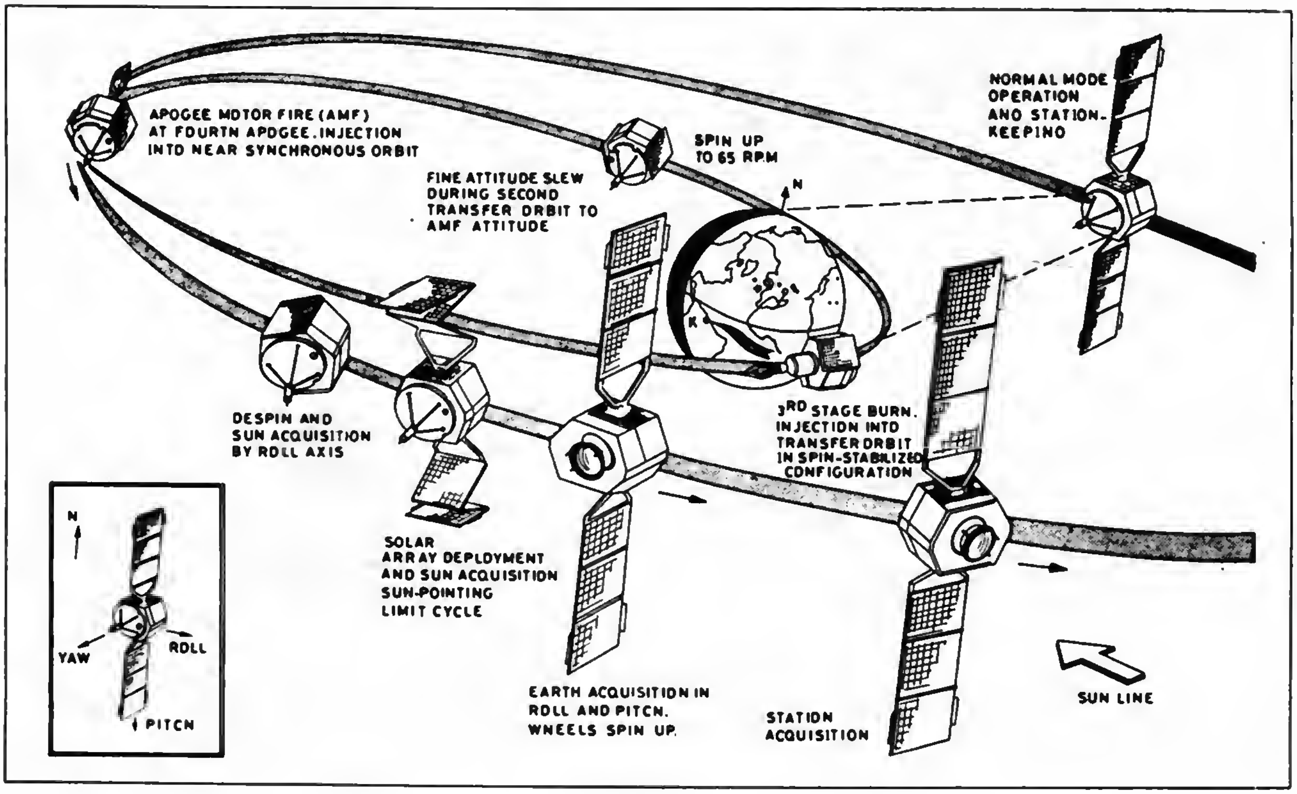
STC's subscribers will share a satellite receiving antenna about 5 to 6 ft in diameter, and the TV signal will be distributed to individual customers through a master antenna TV system. Beginning in late 1983, STC will provide two channels of premium programming without advertising. The first channel will operate 24 hours a day, offering major motion pictures. The second will offer 15 hours of daily programme including film classics, sport, variety and family entertainment, children's programmes, and special interest programmes such as women's, minority-oriented and performing arts shows.

The cost to individual subscribers will total approximately \$22 to \$25 per month (1981 dollars) including the rental cost of the equipment. Individual subscribers will also pay a modest installation charge and a fully refundable deposit.



The Sirio 2 satellite (above and below) is due for launch by Ariane L5 towards the end of April. It has two main mission objectives: Meteorological data distribution on a world-wide basis and synchronisation of atomic clocks using laser beams returned to Earth by reflectors.

ESA



DIRECT BROADCAST BIDS SOUGHT

Direct broadcasting of TV from space to the United States came a step closer in January with the issuing of a RFP (request for proposal) by STC (Satellite Television Corporation), a COMSAT subsidiary, writes Kevin Rooney. Competitive bids are expected from Hughes Aircraft Company, Ford Aerospace, TRW, Ceneral Electric and RCA Astro Electronics.

The FCC (the US communications coordination authority) had previously accepted filings from eight organisations, including STC, wanting to provide TV services to the US. Included in the successful filings was a consortium reflecting British banking interests. The eventual STC requirement is expected to be for six to eight geostationary spacecraft, each relaying three TV channels into different US time zones. The system will use Ku-band (12 GHz) spacecraft employing high power amplifliers of nominally 200 watts RF output.

The initial bids (for two spacecraft) are due in by April and the contract award is expected before Christmas, leading to the first launch in 1986. The eventual market for TV broadcast satellites in the US alone could exceed 50 spacecraft by the 1990's.

NEW TRANSATLANTIC SERVICES

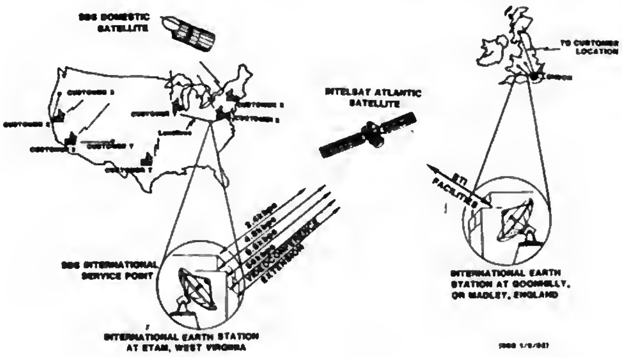
Satellite Business Systems (SBS) of the US and British Telecom International (BTI) have announced plans for the joint provision of transatlantic communications services, inlcuding video teleconferencing, high speed data, and facsimile.

The organisations have agreed to develop and offer a wide range of advanced services, with particular emphasis on digital high speed services. SBS concurrently has applied to the US Federal Communications Commission (FCC) for authority to provide international services as an international carrier. SBS advised the FCC that several of its customers with subsidiaries or affiliates in the United Kingdom have asked SBS to interconnect their UK facilities with their US locations served by SBS. Similarly, a number of British-based companies have expressed strong interest in digital services within the United States interconnecting with the SBS System for service to their operations in the United States.

SBS said its customers have requested transatlantic wideband channels to be used for a variety of applications, including data communications, high speed electronic mail, and video teleconferencing. The video teleconferencing will include digital freeze-frame and analogue full-motion services.

Under the joint proposal, SBS and BTI would use existing Intelsat satellite communications facilities for the intercontinental portion of the jointly provided services (see diagram). The initial service will be at speeds up to 56 kbps.

In the US, SBS has established a domestic satellite system that provides, among other services, flexible, high capacity private networks, which can handle all of a large organisation's requirements for intracompany voice, data, electronic mail, and teleconferencing services. The SBS system employs all-digital transmission in higher frequency bands, which avoid the frequency congestion of lower frequencies and allow virtually unrestricted siting of Earth stations.



UNESCO has awarded a grant of $25 million to help establish the Arthur C. Clarke Communications Centre at the University of Moratuwa in Sri Lanka. Participants will learn to use communications satellite technology for the Third World, and educational programmes will be beamed to Africa, Asia and the Middle East via the Intelsat Indian Ocean satellite. Solar energy and computer technology relevant to the poorer countries will also be studied. Arthur is a long-standing Fellow of the Society and served two terms as Chairman of the Council (equivalent to the office of President today).

In the UK British Telecom has already introduced the first phase of the London Overlay Network, which will offer customers a choice of analogue or digital private circuits with a range of transmission rates up to 2 Mbps. This will be followed by the introduction of a range of national digital network services during the next two years – to be called the X-Stream Services.

In late 1983, a pilot digital switched service called Switchstream will be operated by British Telecom in collaboration with principal business users in London. By 1984, Satstream, British Telecom's small-dish satellite service will offer SBS-like private business communications in the UK and Western Europe.

INDONESIAN COMMUNICATIONS SYSTEM

The Indonesian state telecommunications company, INTI, is working with British and Japanese teams to develop a satellite-based data communication network, which is being procured by the International Telecommunications Union on behalf of the Indonesian Covernment. It is partially funded by the United Nations Development Programme.

Logica of the UK will design and implement the majority of the software, and the Japan Radio Company will supply the small satellite Earth station, other radio equipment and the computer hardware needed for the project.

The project is significant in that it introduces practical modern technology into Indonesia, and much of the work will be undertaken on site using local technicians, including manufacture of some of the radio equipment.

The system to be supplied consists of six small Earth stations (4.5 m) and three urban terrestrial radio networks, together with associated subscriber interfacing and network control and management systems. The satellite to be used is the Palapa domestic satellite, one of the most proven domestic communications systems in the world.

The radios to be installed on subscribers' premises are low cost products and the small Earth stations are also inexpensive. All of the equipment is capable of Indonesian manufacture. The design of the network assumes no existing infrastructure: given access to a suitable satellite all of the necessary equipment can be installed on the users' premises and PTT lines are not required.

It is expected that this technology will find many applications in those developing countries which have urgent but limited needs for data communications.

SPACELAB, SPACE SICKNESS AND THE SPACE SLED

Mario Mutschlechner, BIS Member, interviewed Dr. Ulf Merbold, Spacelab payload specialist, and Prof. Dr. R. von Baumgarten, of the Spacelab SLED programme, at the Physiological Institute of the Johannes Gutenberg University in Mainz, W. Germany, on 24 June 1981.

Mario Mutschlechner: Have you done any training to adapt yourself to weightlessness?

Ulf Merbold: Nobody can predict with certainty what problems they will suffer in weightlessness. I have passed certain tests and have found no problems. It's thought that space sickness is connected with motion sickness but there are other problems in weightlessness, such as the displacement of blood.

MM: Astronauts have reported feelings like those associated with head colds or flying upside down.

UM: Doctors claim that this so-called fluid shift implies the risk of pulmonary oedema, since the relatively soft consistency of the lung tissue is not adapted to this relatively high blood pressure within the lung and in that respect there is a certain risk, but the adaptive mechanism of the human body reduces the plasma volume within a short time. We spent a lot of time in rotating chairs doing head movements to produce symptoms of motion sickness.

MM: ... as was done in Skylab?

UM: Yes, but, surprisingly, the Skylab tests showed that people can take this very well in weightlessness whereas many give up after a short time under terrestrial conditions.

MM: ... they get dizzy ...

UM: ... no, they don't get dizzy but show grave symptoms of kinetosis, i.e. motion sickness. We made many parabolic flights with small planes and also with the big KC 135 at NASA in Houston. In addition to that, my personal experience confirms that there is a big difference if you are strapped down in a small cockpit during a parabolic flight or if you are floating freely in the large cabin of a KC 135.

MM: You're referring to a situation like the first space flights when the astronauts had no problems because they were held tightly in their Mercury or Gemini capsules. Later, in the spacious Skylab, some had problems.

UM: At least that's the general opinion, that the smallness of the spacecraft avoided these problems during the early flights. Later it turned out that these symptoms occurred in about 50 per cent of all astronauts and cosmonauts; the Russians have the same problems. People believe that man, especially during such short missions as the Shuttle-Spacelab missions, which will normally be limited to seven days, will feel subjectively better in such an environment and thus also work more effectively than in an environment without an optical up or down.

MM: That's certainly true for such short mission durations. Why was such a short mission duration chosen, since it coincides exactly with the time during which most people have the worst adaptation problems to weightlessness? After all that's a great risk!-People go up, feel miserable, have a lot to do and maybe are unable to because they feel sick!

UM: All I can do is speculate. The Orbiter is designed primarily to put satellites into orbit, and within this given framework people designed Spacelab. The Orbiter, as a medium for the transportation of satellites into orbit, was conceived for short durations.

MM: ... in other words; you want to say that the Orbiter contains so little space for shirt-sleeved occupants that it would be an enormous stress for the people if they had to live there for more than a week?

SLED, shown here with ESA's Director-General Erik Quistgaard, was to have flown aboard Spacelab 1 but was dropped because of weight restrictions and should now fly with the Spacelab D-1 mission in June 1984. By studying the vestibular function, scientists hope to determine the cause of space sickness.

ESA

UM: I don't share that opinion. The Orbiter is much more spacious than Apollo was and Apollo housed the people for more than a week without producing psychological or other problems.

MM: There are missions of up to 30 days planned.

UM: That's right! The basic configuration of the system allows us to extend the mission duration to 30 days, and I am quite sure that these longer mission durations will be reached quickly. One simple reason is that the costs per take-off are still high, in spite of the fact that it is a reusable system. Once you are in orbit it seems reasonable to use the opportunity and to stay 70 or at least 30 days, instead of seven.

MM: Seven days does seem a rather short period, especially when considering that most people feel rather bad during the first three days.

UM: I agree, but this first Spacelab flight, limited to seven days, has the main task of testing Spacelab under true space conditions.

MM: Now a few more questions in relation to the SLED. What you're trying to understand with this device is a complex matter. Maybe you could briefly explain.

UM: The real expert here at the University of Mainz is Professor von Baumgarten. But I can also present my own point of view. Nowadays, we start from the premise that the information concerning orientation in space comes from different sources. The primary source is the eye. But we have several other sensors, for example the cells sensitive to touch in the skin or the vestibular apparatus of the inner ear. You can maintain your upright position easily even when you close your eyes. But when you enter weightlessness the vestibular apparatus of the inner ear fails for physical reasons and the central nervous systems receives data that make no sense and are physically wrong, erroneous.

MM: ... don't correspond with what you see ...

UM: ... yes, and that produces a conflict of information between the data from the eyes and ears. The result of this conflict is space sickness. People feel ill at ease, which continues for three or four days until the central nervous system has learned that the inner ear is wrong in weightlessness. From then on these data are ignored or suppressed and the data from the eye are accepted as valid by the central nervous system. As soon as this state is reached, the adaptational phase has been overcome and you are adapted to weightlessness. The inverse problem occurs when you return and land on Earth. In spite of the fact that the vestibular apparatus of the ear functions again it is not taken into consideration, and I believe - and Owen Garriott (ex-Skylab astronaut) confirms it - that this unsteady gait of American astronauts on the aircraft carriers is not primarily the result of muscle atrophy, but of the fact that the brain doesn't accept the data of the vestibular apparatus.

MM: They hardly suffered from muscle atrophy, since they exercised sufficiently on board.

UM: Yes, some, like Gibson, displayed a better physical condition after the flight than before.

MM: They also observed in Skylab that the semicircular canals of the inner ear have no influence on orientation in weightlessness.

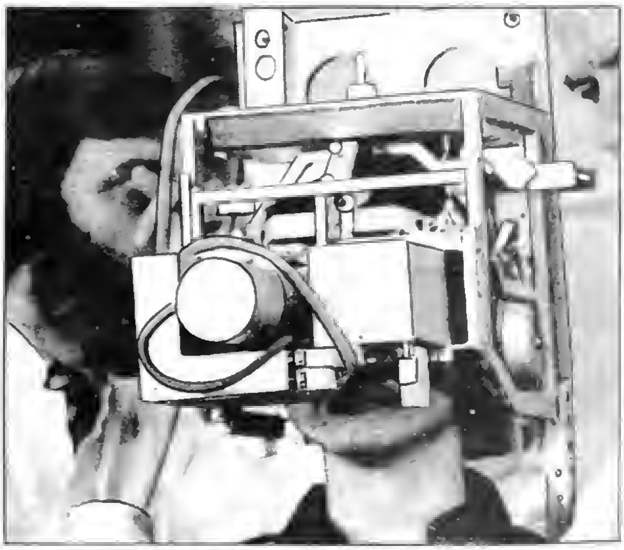
UM: That's correct! The semicircular canals are primarily sensors that measure rotation.

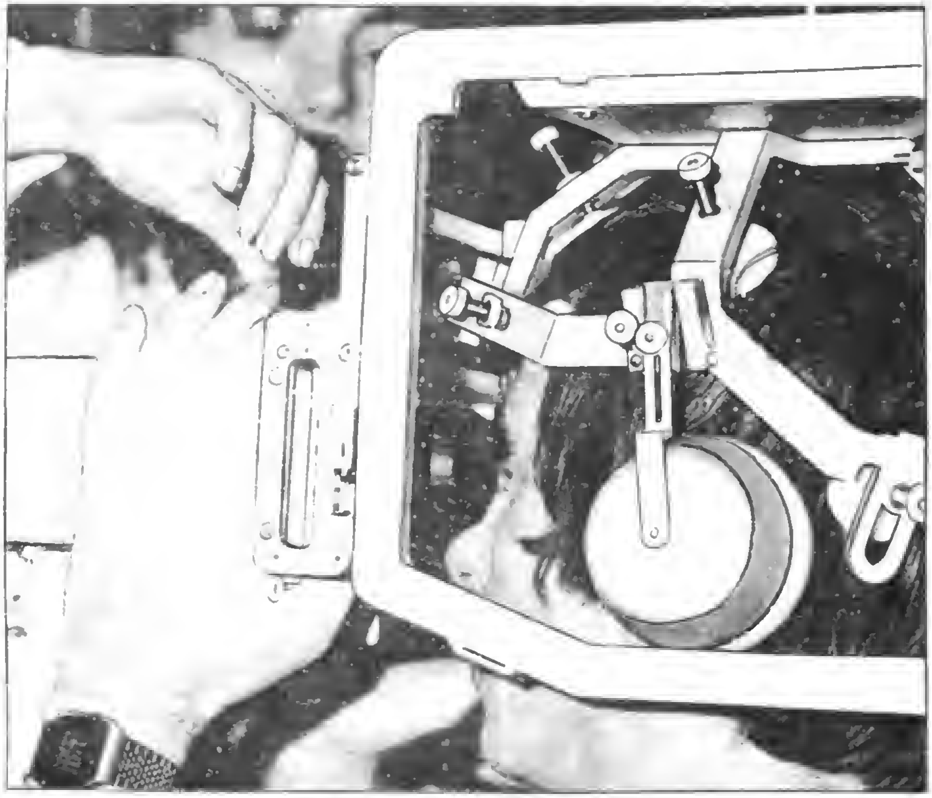
MM: Prof. von Baumgarten, you want to find out with SLED if the otolith is essential for orientation in weightlessness. Could it be that the otolith, too, has no influence in weightlessness?

Prof. v. B: The influence of the otolith in weightlessness is probably a disturbing one. In weightlessness the otolith cannot deliver information that makes sense. Since there is apparently no gravity it cannot indicate the orientation of the subject, but it can still indicate linear acceleration which is always interpreted by the body as inclination. Therefore it delivers an erroneous notification. When a pilot is launched from an aircraft carrier he has the impression that the aircraft is moving upward and consequently steers the plane down towards the water. That happened frequently until the causes were understood. Probably one of the causes of space sickness is that the otolith has a higher sensitivity to linear acceleration in weightlessness than on Earth. That is related to the so-called basic law of sensitivity by Weber-Fechner. If a background stimulus, in this case the Earth's gravity, disappears, the sensitivity to differences increases. Finally the sensitivity to differences increases so much that the astronauts perceive the linear motion of walking back and forth as inclination. This is neither confirmed by common sense nor by the eye. Therefore it is a conflict, and the modern hypothesis of motion sickness implies that it (sickness) occurs always when conflicts occur. But the semicircular canals are not the cause of the space sickness - that has been determined in the Skylab experiments. You may provoke the canals and it doesn't lead to space sickness. Therefore we believe that the semicircular canal system has less to do with the space sickness than the otolith system. To

Spacelab payload specialist Ulf Merbold demonstrating the helmet facility. The helmet contains a camera and equipment to measure the subject's reaction to motion in weightlessness. *Below*: the helmet in place.

ESA





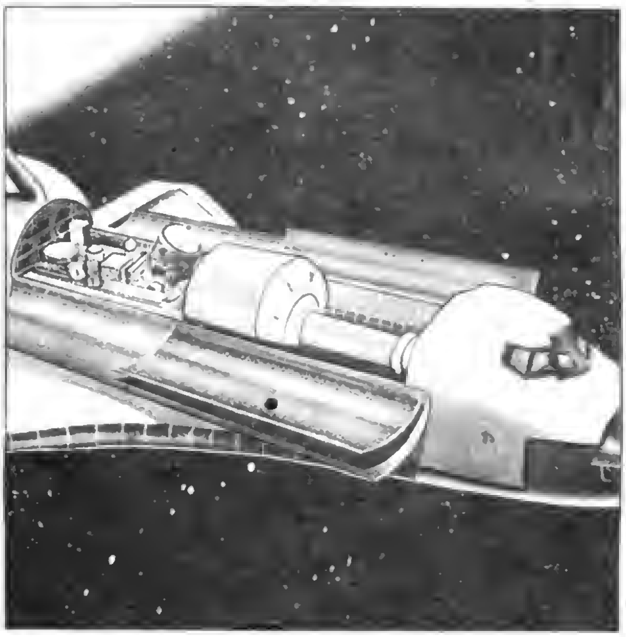
Side view of the SLED helmet.

ESA

put it in other words: Space sickness is otolith-connected and not semicircular canal-connected.

MM: So you believe that we will be able to detect sickness-prone astronauts?

Prof. v. B: At the moment we don't know. Unfortunately it's very difficult since the number of space travellers is too small to get statistically useful results considering the large individual differences. It is not only a matter of selecting the candidates but also of preventing space sickness. We need methods to prevent the difficulties of the first days. We have developed a helmet which registers eye movements optically to help in our experiments.



Spacelab flights are scheduled to take place in September 1983 (SL-1), June 1984 (D-1), and November 1984 (SL-2). SL-3 will probably be in 1985.

ESA

MM: You refer to the optokinetical part of the helmet?

Prof. v. B: Yes, and especially to the counter-rolling of the eyes - one of the very few tests for the otolith apparatus. Clinically, very few tests exist for that purpose. One is the luminous line test, and the other is the eye counter-rolling test. Up to now the latter could only be recorded using individual still photographs but now we are able to get a complete eye motion record. Subjects put on the helmet, tilt the head to one side and then we measure if their eye counter-rolls or not. If the eye doesn't counter-roll you can say with considerable probability that the otolith apparatus is damaged, even if the semicircular canals are in perfect condition. Until now it was impossible to distinguish this.

UM: It is certainly a mean idea, but I have gathered from my training so far that the best space traveller is the one whose otolith has been excised pre-flight. Once it is eliminated it cannot measure erroneous information. And obviously somebody with a damaged inner ear is relatively insensitive to motion sickness.

MM: On the other hand, people are capable of adapting to weightlessness. But they don't remain continually in zero g, they are also accelerated and then it is probably a help to have the otolith. ...

Prof. v. B: That is a mistake. I maintain that there is nothing worse for the otolith system than linear acceleration, because then it always gives the wrong indications. The otolith apparatus is there for one purpose: to measure the direction of the gravity field of the Earth in relation to the axis of the head. If you travel aboard a jet-liner all you have to do during take-off is to close your eyes. In spite of the fact that the plane is still rolling horizontally on the field you feel already as if it were climbing. Give it a try!

JOHN YOUNG – ONE MAN'S CONQUEST OF SPACE

By David J. Shayler

PART ONE

On 12 April 1981, exactly 20 years after Soviet cosmonaut Yuri Gagarin became the first person to fly in space, an American astronaut set a new World record by becoming the first to fly five separate space missions.

In a career spanning almost two decades, John W. Young has become one of the most popular and successful space explorers, achieving several notable accomplishments in his early Navy flying career, in space and in the numerous assignments between flights.

Even before Shuttle *Columbia* had cooled from its fiery re-entry, Young was looking to the future and to the prospect of making a sixth and even a seventh spaceflight.

John Young, commander of the first Shuttle orbital mission at the age of 40.

NASA

The Early Years

Life for the future astronaut began on 24 September 1930 when he was born in St. Luke's Hospital, San Francisco, California. He was named John Watts Young. His parents were then living in San Mateo, California and his father, William H. Young, was employed as a Sales Engineer for the Raymend Concrete Pile Company. He was the grandson of the late Dr. and Mrs. Mank Young, and a grand nephew of the late Dr. and Mrs. Will Young.

Even at a very early age, baby John revealed a keen interest in mechanical toys which, according to his father, always brought a sparkle to his green eyes. He was only 18 months old when the depression caught up with the construction industry, forcing Young Senior to move his family back to Cartersville, Georgia where he had been born in 1902. In 1933 John became an older brother when his mother gave birth to her second son, Hugh.

The School Years

John's education began in 1935 when he attended the Cherokee Avenue School for two years, living at his aunt's home. His aunt, Mrs. Harry M. Hebbie, soon noticed his early interest in model trains and aircraft, describing him as a very bright and brilliant youngster.

Throughout his life several people have been credited with giving John a very early start in his distinguished career. One was his early second grade school teacher at Cherokee, Miss Dinks Irick, who described the future astronaut as a "brilliant boy, always a pleasure to teach". Miss Irick could not recall him pulling any school pranks, remembering him as a very serious child.

By now his father had found work and sent for his family to join him. It was 1936. Six years-old John found himself in Orlando, Florida, but not permanently. For the next three years John, who had by now shown a keen interest for flying and aircraft, and his younger brother constantly moved back and forth between Cartersville and Orlando while their father found a more permanent home for his family. Finally, in 1939, the family moved completely to Florida to set up home at 815 W. Princeton Drive, Orlando, where John and his brother spent their remaining years of childhood. It was this early attachment to Orlando that has been credited for his accent which has been described as "pure grits and redeye".

During these early years in Orlando he took more interest in model aircraft and constantly dreamed of flying in the blue sky through which he constantly watched such aircraft as B-17's and P-38's flying from nearby stations.

To supplement his interest in model aircraft, and to earn extra pocket money, he was employed as one of the youngest newspaper carrier's in Orlando. While delivering copies of the *Orlando Sentinal* during 1939–40, little did he dream that one day his name would regularly hit the front page headlines as he flew much higher than his beloved Orlando skies [1].

He now attended new schools and was described by his fourth grade teacher at Princeton Elementary School, Miss Anabelle Reeves, as one of her best students, a "very normal boy, who always did what he was supposed to."

To his family, teachers and friends John always appeared to have a mission in life, though in those years this tended to lean more towards playing soldiers or American Football and baseball with his best friends Powell Sheffer, Calvin Steele, his younger brother Hugh or cousin Joe Akerman.

His hobby at this time was H0 and 00 gauge model railways and trains. He continued to keep his eyes skywards, though, and according to his cousin John, continually built and flew model aeroplanes with great success. His talent for drawing became a trademark of the young designer whose intricate aircraft plans and construction sketches seemed to point towards a distinguished association with aircraft and flight in the future. Throughout his school years he was also involved in the Boy Scout movement.

Never one for the limelight, he was never to be found in any of the school group photographs. Indeed, according to another of his former teachers, Mrs. Miriam B. Thomas, his sixth grade teacher who later became a principal at Princeton, he was "rather retiring" but was nevertheless "a good natured person but never onc to push himself forward, though he was very well liked by his fellow pupils."

By now, the USA had entered the Second World War and

Young (right) with his commander for the Gemini 3 flight in 1965, Gus Crissom. Note the resemblance between these Gemini spacesuits and the Space Shuttle ejection suit shown on the previous page.
NASA

John's father was in the services as a Commander in the Navy's SeeBee's stationed in the Pacific. His mother was ill in hospital and the two brothers were being looked after by their housekeeper, Mrs. Elza Smith.

According to Mrs. Thomas the future astronaut achieved straight "As" in her class despite the fact that she did not give easy grades. He was an all-rounder, outstanding in both academic studies and sports. An old Princeton School Christmas programme shows his name as one of the two sixth grade narraters. In the very same school year he served as Captain of the school patrol boys, gaining this position due to his high ratings in citizenship as well as scholarship.

Always a leader, he was an outstanding scholar, top school athlete and a well-respected citizen. John Young, even at this early age, was already showing signs of the so-called "Right Stuff."

Continuing his education, he went on to the Memorial Junior High School, playing football for his school in the ninth grade, and then on to Orlando High School.

Higher Education

By now John's much-loved bicycle was in the back of the family garage. His transport was a 1936 Ford owned by his backyard neighbour and best friend Calvin Steele. While keeping up his grades and his athletic prowess to what would become a constant peak level, he still found time to take his girlfriends to shows on Saturday night, then to meet "the gang" at the Old North Pole Drive-In, North Orange, Florida, for a Coke before a ride down the "drag" in Steele's Ford.

As he grew older he took on more responsibilities. He began to work during Saturdays and one of his summer jobs was as a rodman with surveyors Nettles and Heath, who said that Young was the hardest working youngster they ever had.

Then, one day, without any previous hints to anyone, he started a new interest and switched almost all of his spare time efforts to rockets and rocket techniques (before most of his school mates knew such subjects existed). Around this time he had also become a fan of Buck Rogers, which may have helped to spark his own desire to travel in space.

According to cousin Joe Akerman, later to become a lecturer at Stanford Junior High School, John had to conduct a lecture as part of his annual project in the 11th grade in 1946. For John this was easy - he chose rocketry. To most of his fellow school mates and even his teachers, such a subject was a little strange for a 16 year-old at that time, but he gave a very successful lecture.

A firm favourite with his classmates, he was said to be full of integrity and fair mindedness. These characteristics won him places in the Memorial Junior High School Torch Society and subsequently Orlando High School Honor Society which, on Graduation day in 1948, earned him the highest award of the senior class - the Guernsey Good Citizenship Cup.

Ironically, one of his fellow classmates, Majorie Mackstroth, in her graduation speech told the class of 1948 that they, in their future years would be "going places". "There are new fields to conquer," she predicted, "... new horizons to reach in science and technology." Little did she realise that John Young, sitting behind her with the rest of the class, the same boy who had bought her Cokes at school dances, would be one of those to attain and surpass these goals.

Always described as the kid-next-door type, he was a quiet scholar, a high school football right guard, and a graduate year track star. His passion for running and handball continues, and he has always been grateful for the education he received at Orlando High School. "It gave you a darned good background for engineering and basic education. If I knew then what I know now," he reflected years later, "I think I would have taken not only engineering subjects, but some other things like public speaking and more English".

Following graduation from Orlando High School the next stage in his education was at the Georgia Institute of Technology under a Naval Reserve Officer Training Course scholarship. Majoring in Aeronautical Engineering he attended the Institute from 1948-1952, graduating second in his class and obtaining a Bachelor of Science Degree in Aeronautical Engineering with Highest Honours. In addition, Young contributed articles to the Institute's engineering magazine [2].

Some 20 years after his graduation, the former "Wramblin Wreck from Georgia Tech" was preparing to fly to the Moon for the second time. His former Professor, in writing to the Director of the School of Engineering Sciences and Mechanics at Georgia Tech, admitted to committing an error.

"In reviewing my past class records, I have come upon a judgement error I made in the winter of 1951," wrote Dr. Kenneth Jacabs. "I feel that, in the interest of justice, the error should be rectified". He stated that the D grade in engineering should be changed to an A for Young who had since proved "he knows something about complex machines", which would be in line with his otherwise excellent grades.

When Young learned of this petition he wrote to Dr. Jacabs, "Thank you for the Mech. 302 grade change consideration. Unfortunately, I can assure you that the D Grade was earned fair and square, therefore I would appreciate it if you would let the grade remain a D. It would grieve me considerably to think that Georgia Tech. was getting soft or that the Tech. Professors ever made 'errors of judgement' that they would admit to anyone. After all Georgia Tech. is an outstanding - but tough - engineering institute. Yours for keeping it that way, Warm regards, John Young"[3].

Into the Navy

Following graduation from the Institute, Young decided to continue his career in the US Navy, joining the service in June 1952 and applying for flight school. Unfortunately, his appli-

cation was delayed for some reason and he was dispatched for a one year tour of duty on the Destroyer *USS Laws* (DD 558) until June 1953. Serving as a Fire Control Officer he completed a tour detachment in the Korean Seas. Many years later, when training for his first spaceflight, Gus Grissom would never let him forget his "black-shoe Navy days"[4].

Finally, his application for flight training was accepted and in June 1953 he reported for duty at the Naval Basic Air Training Command at Penscola, Florida. It was not long before he gained his wings and found his big love for flying. At last he was among the clouds he had gazed at from the ground as a youngster, though it very nearly never turned out that way. "I almost decided against becoming a pilot, because, as a knowing engineer, you have to wonder about the safety factor", he once said [5].

From June to December 1954 he furthered his experience in a six month course at the Navy Advanced Training School at Corpus Christi, Texas. Following graduation, he was assigned to the Jacksonville Naval Air Station in Florida, in January 1955, beginning a four year tour with Fighter Squadron 103 completing two tours on the aircraft carriers, *USS Coral Sea* and *USS Forrestal*.

It was after graduation from the Navy Advanced Training School that he met his future wife Barbara Vincent White, formerly of Savannah, Georgia, but resident in Jacksonville. They were married in 1955 while Young was stationed with Fighter Squadron 103. This was followed by two further important moments in John Young's life: on 30 April 1957 his first child was born (a daughter they named Sandy), then on 17 January 1959 a second child was born, a son, who would be named after his father, John.

The following month, in February 1959, he took up a new assignment at the US Naval Air Test Center at Patuxcent River, Maryland as a student on a Naval Test Pilot course. He passed with flying colours. At the completion of the course he stayed on at the Center as a test-pilot. Working on several projects, including the F8D and F4B weapon systems, he was Project Manager, writing technical reports and summing up the results of the test programmes for preliminary evaluation by the Navy. During one of his many test flights his piloting skills were well tested.

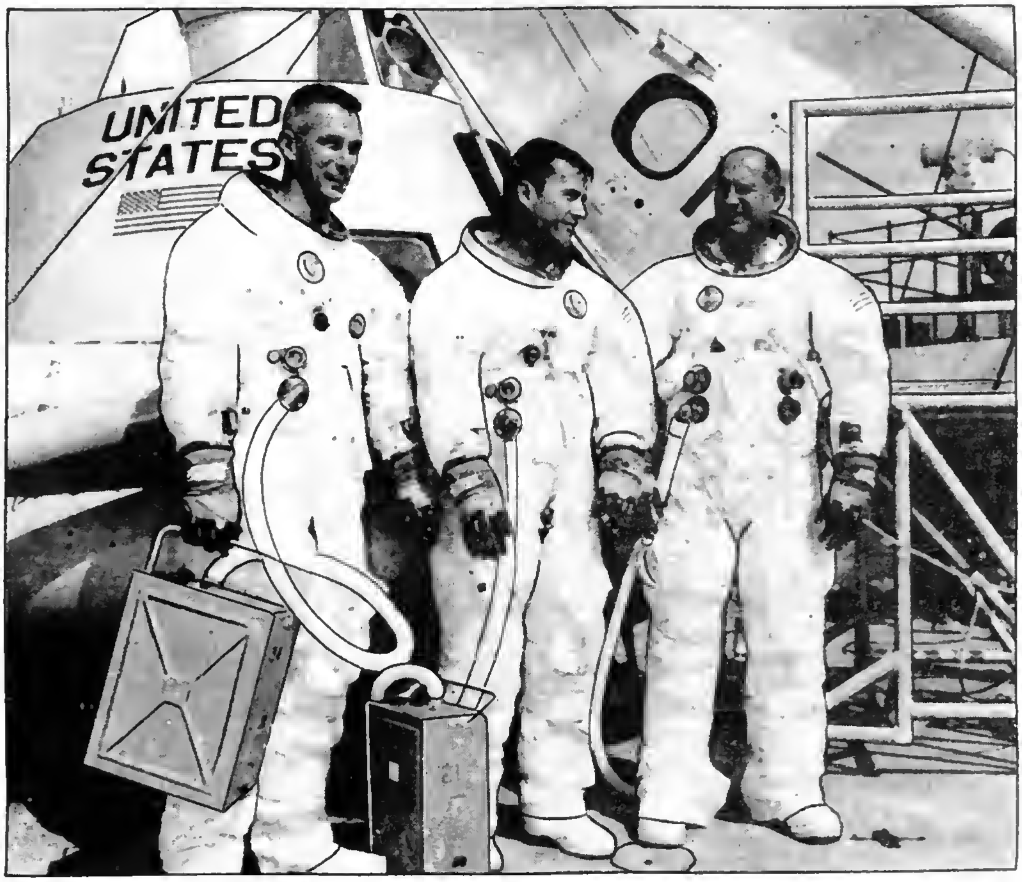
He was engaged with another pilot in a test programme of evaluating air-to-air missiles with the two aircraft approaching head on at three-times the speed of sound. But at this close range a sonic boom could shatter the cockpit windscreens, or a slight miscalculation could have spread pieces of expensive aircraft all over the surrounding area.

Luckily it was a simple operation for Young, and the two pilots later landed safely. A little later he received a note about the episode: "I got a telegram from the Chief of Naval Operations asking me not to do this any more," he said with his usual wry smile [6]!

Next in his naval assignments was as a pilot in the Phantom time-to-climb series of record-breaking flights under the label "Project High Jump."

Lt-Cdr Young set the World time-to-climb record for the 3,000 m of 34.523 seconds on 3 March 1962. His first record-breaking flight was set at the Navy Air Station at Brunswick, Maine. He opened full after-burners while still standing still on the runway, being waved off, before the engine reached full power, by the timing officials. Young released the brakes and screamed down the runway, retracting his undercarriage immediately after takeoff, and accelerated in level flight until he had attained the pre-determined speed. He then pulled up at the pre-planned rate of change of g and a specific peak g until the desired climb angle had been reached. His Phantom F-4B aircraft went successfully through the 3,000 m mark in just over half a minute, with Young achieving a further push towards the stars [7].

The second record flight, the seventh in the series, was set



Crew of the Apollo 10 lunar mission in May 1969 (left to right): Cernan, Young and Stafford.
NASA

from the Naval Air Station at Point Magu, on 3 April 1962. After take off Young again followed the pre-set procedure, attained an intermediate altitude, accelerated to supersonic speed, and then pulled up into a climb. He reached the 25,000 ft level in 230.44 seconds, this time in an F4H-1 Phantom [8].

By now John Young was looking much higher than 25,000 ft. A few weeks earlier he, like millions of fellow people, followed the historic mission of John Glenn during the three revolutions in Friendship 7. He was so enthralled with the event on TV that afterwards he began urging all of the test pilots he knew to apply for the space programme which, of course, included himself.

Entering the Astronaut Programme

When NASA issued the call for a second group of astronauts in April 1962, John needed no persuasion to add his name to the list of applicants before the cut-off date of 1 June. It was a logical progression in his career. He met nearly all of the selection requirements: he was a military test pilot with an engineering degree; three years inside the age limit of 35 and at 5 ft 9 in he stood three inches below maximum height (though it later turned out that his shoulder width of 19.9 inches was the widest of any of the first 16 astronauts selected in Groups 1 and 2!). Young now continued his Naval duties waiting for the word that his application had been accepted and, after the series of tests, examinations and interviews, hoping he may be one of the 5 to 10 men expected to be selected for the astronaut training programme [9].

As he waited for the closure of the application period, he completed his duties in the High Jump programme and in April 1962 was assigned to a new position as Phantom Maintenance Officer, Fighter Squadron 143, an All-Weather Fighter Squadron at Miramar in California. He stayed there until October 1962 and it proved to be his last assignment as a Naval Test Pilot.

Early in July 1962 he was summoned as one of 253 suitable candidates for a five day series of exhaustive medical tests and examinations at the Air Force School of Aerospace Medicine at Brooks Air Force Base in San Antonio, Texas. The medical programme for the selection was not so experimental as for the Original Seven three and a half years previously.

Even so the examiners probed, prodded, pushed and peered in every conceivable place on the applicants' bodies. This was followed by a series of interviews with NASA doctors, psychologists, engineers, scientists and administrators, and some of the Original Seven astronauts, for a final check of the 32 finalists. For this series Young and the other potential astronauts stayed under fictitious names at the Rice Hotel, with the interviews being held in Houston [10].

Young and the other 31 candidates returned to normal duties while their applications, medical results, examination papers, interview reports, service records and personalities were all investigated and analysed. Then, in early September 1962, Young received a telephone call asking if he was still interested in joining the programme and if he would report to Houston as a successful member of the second astronaut group. For John the answer was a definite "Yes."

Young and the other eight men who were to form NASA's second group of astronauts were officially presented to the press on 17 September 1962, by Dr. Robert Gilruth, Director of the Manned Spacecraft Center (later the Johnson Space Center), Houston. They were selected for the forthcoming Gemini series of missions and for the early flights in the Apollo lunar programme. John Young had reached the pinnacle of America's top pilots just one week before his 32nd birthday.

He, like the others of the second group, was not scheduled to report to NASA until October 1962 to allow time to tie up current assignments, and to make arrangements for moving families to Houston.

On 3 October 1962 he and the other eight new astronauts were on hand at Cape Canaveral to witness the flight of Wally Schirra in Sigma 7.

"I was really impressed with it from start to finish," he commented the next day, "I'm really looking forward to it myself, all of the new group (of astronauts) are highly motivated, and we are all hot to go. I'm awed to be in among them, they're a good bunch and it's a tough row to hoe," he stated, "but competition never hurt anybody, and our comparison will I'm sure be good for the programme"[11].

To be continued

Acknowledgements

In the preparation of this paper the author wishes to express his thanks for the assistance of Rex Hall, Curtis Peebles, and Keith Wilson. Special thanks are also due to Lee Saegesser, NASA Archivist, NASA Headquarters, Washington D.C. who supplied valuable information for the compilation of this paper. In addition to the quoted references in this and subsequent parts, the author freely sought further information from *Flight International, Aviation Week, Spaceflight, NASA Activities, NASA Astronaut Biographies 1962–1980*, English and American National Newspapers 1962–1981; NASA official reports on Gemini 3, Gemini 10, Apollo 10, Apollo 16 and STS 1. Also, several publications were freely consulted, such as Petersens' "Man in Space" series; the books by former astronauts Collins, Grissom and Cunningham (*Carrying the Fire, Gemini and The All-American Boys*); *Apollo Expeditions to the Moon, Shoulders of Titans, Chariots for Apollo; Gemini Chronology, Apollo Chronology Vol I–IV*.

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11. *Orlando Sentinal*, Thursday, 22 November 1962, p. 10E.

NEW SOCIETY TIES

A new style of Society tie is now available, dark blue as before and showing the BIS logo just below the knot.

The cost is £6 (£6.50 or $15 abroad), post free.

N.B. Where the new style tie is not specially asked for the "standard tie" will be supplied.

NEWS FROM THE CAPE

By Cordon L. Harris

SECOND SHUTTLE CONTAMINATION

A desk-sized Induced Environment Contamination Monitor carried on the second Shuttle orbital mission provided the first data about the Shuttle cargo bay in orbit. Project Scientist Edgar Miller of the Marshall Space Flight Center reported that every contamination-producing event (thruster firings and water dumps, for example) was clearly identified. Since the mission was cut short, however, insufficient data were obtained to evaluate the extent of contamination. The worst case was expected to occur when the payload bay was exposed to the Sun but that did not happen during the 54 hour flight.

The 10 instruments revealed that humidity remained low during ascent and descent, particles larger than 5 microns were scarce but those smaller exceeded predictions. The cargo bay was sealed successfully from engine by-products during ascent and descent. Water molecules and other early mission contaminants began boiling off rapidly to a 90 per cent reduction after 35 hours in orbit.

"In one instance," Miller commented, "the Orbiter was flying with the open bay pointing straight ahead. Molecular readouts were high because Orbiter-generated particles were deflected by the atmosphere back into the bay. Such instances must be avoided when sensitive telescopes and other scientific instruments are in use."

NEW SHUTTLE FACILITIES

Anticipating increased launch rates, NASA will invest $13 million for additional Shuttle facilities in 1982. A third firing room of the Launch Control Center will be outfitted for Defence missions, the first involving STS-4 tentatively scheduled for mid-July. More buildings will be constructed to process and store solid booster rockets: a main structure 100 feet high equipped with two 200-ton capacity cranes, capable of storing two sets of boosters to support 20 launches per year. Each rocket contains four segments with a total of 1,110,000 lb of propellants.

The External Tank for STS-3 is transferred into the Vehicle Assembly Building at the Cape.

NASA

SHUTTLE LOSES PAYLOADS TO ARIANE

Three US communications companies have contracted for five Ariane satellite launches, the first in December 1983, the others in 1984, because the ESA vehicle will cost them about $20 million per launch in contrast with a price tag of $27 million for the American Delta vehicle.

Western Union, General Telephone & Electronics and Southern Pacific Corp. chose the European booster. While NASA believes its reusable Shuttle will be competitive with Ariane because it can carry several spacecraft in one mission, the agency recognises that users wanting their satellites to reach geo-stationary orbit must pay $3–$5 million extra for booster rockets.

FOURTH SHUTTLE TANK

The external propellant tank for STS-4 began its five day journey from the Michoud Assembly Facility in New Orleans to the Kennedy Space Center on 17 January.

After arriving at the Kennedy Center aboard NASA's "Orion" barge, the tank was moved into the Vehicle Assembly Building for flight preparation.

ELECTIONS TO COUNCIL

The Report of the Scrutineers on the ballot papers counted up to and including 31 January 1982 was as follows:

Number of Papers received 922

The number of spoilt Papers was one. The number of incomplete voting Papers exchanged was two.

The names of the candidates and the number of votes cast for each was as follows:

Position	Name	Number of Votes
1.	C. V. Groves	745
2.	A. R. Martin	705
3.	M. R. Fry	595
4.	C. V. E. Thompson	571
5.	W. F. Hilton	338
6.	C. F. Phillips	262
7.	C. F. Radley	244
8.	D. J. Richer	225
9.	I. C. Mackinlay	50

The four Candidates receiving the highest number of votes and who were accordingly declared elected were:

C. V. Groves　　A. R. Martin
M. R. Fry　　C. V. E. Thompson

THE MILITARY ROLE IN THE SHUTTLE

By Cerald L. Borrowman

Introduction

The US Department of Defense (DOD) has a major management role in the Space Transportation System. Working in conjunction with NASA, the DOD will be a major user of the Shuttle – the first 487 Shuttle missions, which are expected to begin late this year, have 25% flown exclusively for the military. The majority will be for the Air Force, DOD's executive agent for the Shuttle programme. In March 1977, Secretary of Defense Harold Brown designated the Commander, Air Force Space Division, under Air Force Systems Command, as the DOD Manager for Space Shuttle Support Operations.

The term "Space Shuttle Support Operations" refers to those DOD operational support elements associated with the NASA development phase of the Space Transportation System (STS) which are beyond the scope of the Air Force research and development responsibilities.

To assist in the operational phases of Space Shuttle support activities, the DOD Manager has, in turn, appointed the Commander, Space and Missile Test Organization (SAMTO) to Vandenberg Air Force Base, California, as Deputy DOD Manager.

The role of the DOD in the Space Transportation System was described in dramatic terms by ex-astronaut Brigadier General Thomas P. Stafford "... that without the DOD behind the Space Shuttle to utilise this (system) you would have had a very meagre programme. Probably just one launch site and a couple of birds. But I'm optimistic that we will build a total of five to start with."

Air Force Organization

In October 1979, the Space and Missile Systems Organization was transformed into the Air Force Space Division. Major General John E. Kulpa, the Deputy Commander for Space Operations of Space Division explained, "We did this by separating out the responsibility for ballistic missiles to a separate office. This was done to focus the attention at Space Division on space.

"In September 1980 our new organisation was founded. We are concerned with the planning, management of Shuttle operations, and in assisting the development of safety and security policy for DOD and national security missions.

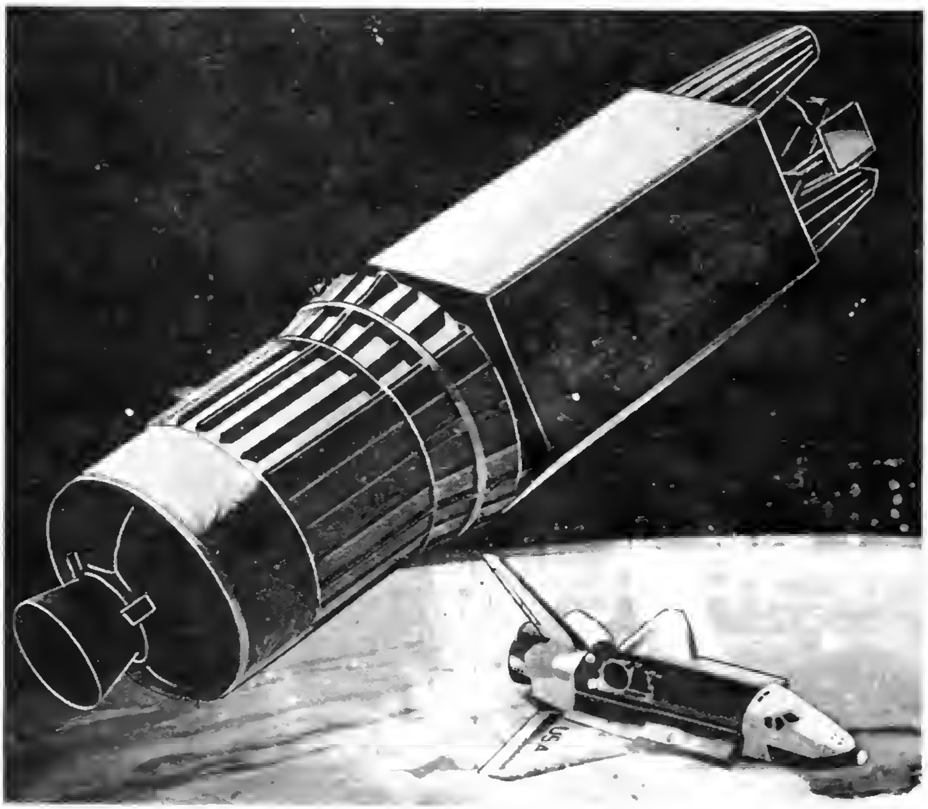
"In addition, the Deputy Commander for Space Operations is manager of the worldwide Satellite Control Facility. The remote tracking stations at seven different locations throughout the world and the hub at Sunnyvale report to us.

"We are working with NASA to maintain a credible launch requirement space line. Through interaction with the programme office at Space Division and the mechanism of a flight control working group, we update the mission model on a quarterly basis. In support of this, we investigate cargo mixing candidates and identify compatible payloads to assure that DOD has full use of the Shuttle capability.

"We work with new programmes that are just on the drawing boards in Space Division. In the planning stages it is necessary to determine the feasibility of a mission, what orbits are possible and to understand the capabilities of the Shuttle. This data base is maintained through the management of the Deputy Commander for Space Operations."

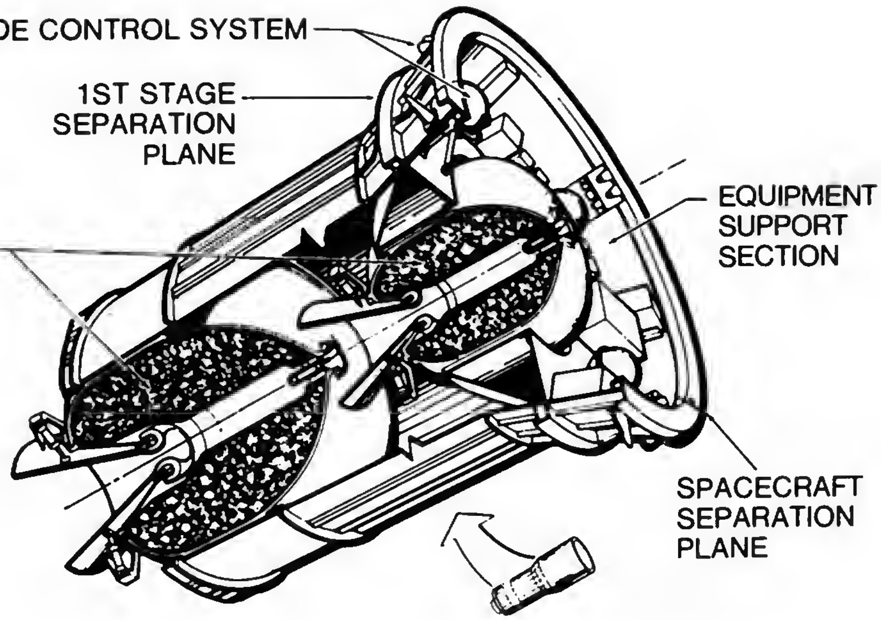
The Air Force Space Division is the focal point with the DOD for plans and activities relating to STS. It provides and manages the majority of the nation's military space systems, is responsible for everything from research and development to on-orbit command and control of operational satellite systems.

As part of an effort to determine DOD's future ability to fully exploit the Shuttle's unique capabilities, the Air Force completed a study in the late 1970's on the need for a dedicated



Artist's concept of the Inertial Upper Stage and its payload, following deployment from the Shuttle's cargo bay. The two stage IUS, with the most reliable avionics system ever developed for unmanned missions, is capable of delivering 5,000 lb to geostationery orbit. It will see extensive service.

Boeing Aerospace



The basic two-stage IUS vehicle. Variations in mission requirements can be handled by different propellant loading. The present contraet calls for eight two-stage versions, and one three-stage. Some will fly on the Titan III expendable launcher.
Boeing Aerospace

DOD Shuttle Operations and Planning Center (SOPC). A phased approach for SOPC is planned whereby Shuttle control capabilities will be added as needed into the single new consolidated DOD facility (CSOC).

The CSOC will consist of two elements, the Satellite Operations Center and the Shuttle Operations and Planning Center. It will combine in a single facility all of the elements necessary to conduct both Space Shuttle and satellite mission operations. In this way, Shuttle survivability will be improved since the Mission Control Center and CSOC will provide a mutual backup, and the Air Force will have a dedicated Shuttle control capability which will permit full Shuttle exploitation for military missions. Until the Initial Operating Capability (IOC) of the CSOC is achieved, all DOD mission planning, simulation, and training will be conducted from the Johnson Space Center.

In order to protect the security of payload data at the Johnson Space Center, the Air Force is currently modifying facilities there. These modifications are referred to as providing a "controlled mode" which is to protect classified DOD mission data with minimum impact on civil Shuttle users.

When fully operational, the CSOC will employ approximately 300 military, 100 Air Force civilian and 1400 contract personnel.

The satellite operations centre will perform communications, command and control functions for orbiting spacecraft while the Shuttle centre will conduct DOD flight planning, readiness and command and control functions.

In mid-March 1981, the decision was made to locate the CSOC in the area of Colorado Springs. This will provide unique operational advantages because of the proximity of the Space Defense Operations Center (SPADOC) of the North American Air Defense Command at the Cheyenne Mountain complex.

It is the responsibility of the Deputy Commander of Space Operations to define the requirements and the operational capabilities of that facility. It will conduct both Shuttle launch operations and satellite on-orbit operations.

In the near future, the CSOC will not have an identical simulator to that which NASA has installed at the JSC for simulation of liftoff, on-orbit activities, and recovery. Rather, the DOD will focus on the in orbit portion of the flight. In the long-term, DOD will acquire a full Orbiter simulation capability to support the full mission model.

The CSOC will achieve its Initial Operational Capability, according to the present plan, in around 1986.

The Air Force personnel of the Manned Space Flight Support Group started arriving at the Johnson Space Center on 1 June 1979. Over the previous year the size of the group had grown to 54. A member of the team is a 23-year old blue-eyed blonde who was a May 1980 graduate of the Air Force Academy. Second Lieutenant Dianne Langmade was one of the 98 women in the Academy's first class to graduate women and she is the first female Air Force officer to be assigned to the Johnson Space Center. She will join NASA flight controllers to learn the operation of the thermal systems console in the Mission Control Center during Shuttle missions. She will be responsible for monitoring performance of the Orbiter's passive and active thermal control systems.

Inertial Upper Stage

The Air Force Space Division also has responsibility for the development of the Inertial Upper Stage (IUS). The basic two-stage IUS consists of two solid-propellant motors (one with 21,400 lb of propellant, the second with 6,000 lb), an equipment bay, and an interstage structure. According to its design performance, it will be able to place a 5,000 lb payload into geosynchronous orbit with an accuracy at least equal to that of the Titan IIIC. The two-stage IUS will be able to place 11,000 lb in orbit at an altitude of 4,200 nautical miles with 12 degrees of plane change; deliver 2,000 lb to orbit at 48,000 nm with 120 degrees of plane change, or perform any mission in between.

Obviously the IUS offers the spacecraft community a highly reliable, cost-effective upper stage with built-in flexibility and adaptability for integration with both the Shuttle and Titan III.

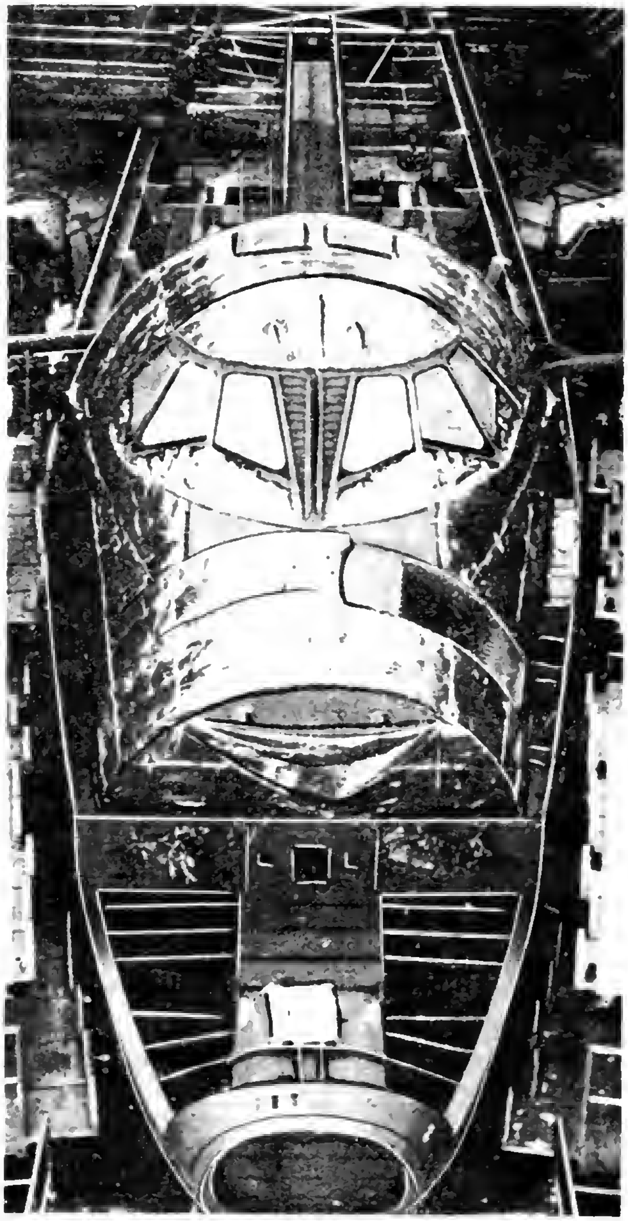
By adding an equipment support module, IUS can serve as a spacecraft and save users the cost of developing their own avionics. It can also be used for low-altitude sortie missions. With this option, scientific packages can be transported away from the Shuttle environment and then retrieved for analysis and re-use on subsequent flights. Another cost-saving alternative is to use the extra space weight not taken by primary spacecraft to carry experiments that only require IUS for placement.

Preparations for operation from the Kennedy Space Center primarily involves the Solid Motor Assembly Building at the Titan Complex (ITL – Integration Transfer Launch) within the Cape Canaveral Air Force Station. The facility is currently used to stack the elements of the Solid Rocket Boosters of the

Titan, while the east wing is being modified to allow the entire IUS to be assembled there. Then it will be taken over to the west wing of the building where a Shuttle Payload Integration Facility (SPIF) will have been built. The payloads are to be checked out in the SPIF and then integrated with the IUS. The combination will be placed in a NASA canister and transported to the launch pad by way of the Rotating Service structure and placed in the Orbiter's cargo bay.

Vandenberg Operations

The Space and Missile Test Organization is headquartered at Vandenberg AFB and serves as Space Division's test arm, managing and directing two centres which perform launch and range operations. The Western Space and Missile Centre at Vandenberg AFB launches spacecraft requiring polar-type orbits using range resources situated on the California mainland and in the Pacific.



Shuttle Orbiter *Challenger* under construction in California. Following delivery this summer it will join Orbiter *Columbia* in the launch schedules.

Rockwell

Space Shuttle technical management will be conducted by the 6595th Shuttle Test Group, part of the Western Space and Missile Center. The 6595th STG will oversee all Space Shuttle contractors at Vandenberg and coordinate and direct operations.

The Space Transportation System Program Office, part of the Space Division at the Los Angeles Air Force Station, is the overall manager for the development and acquisition of Vandenberg Space Shuttle facilities and systems..

Nearly 75 members of the Eastern Space and Missile Center were directly involved in the launch of STS-1.

"Ever since the Shuttle rolled out of the Vehicle Assembly Building . . . the excitement of our people has been building," said Lt. Col. George A. Stetz, Chief of Space Shuttle Launch and Landing Operations, 6555th Aerospace Test Group at the Cape Canaveral AFS.

"Eight Air Force members have been totally integrated into the Shuttle operations," said Col. Chuck Kuhlman, chief of the group. These people share offices with their NASA counterparts, and often have two bosses, NASA and the Air Force commanders.

"Our people have been performing many of the same types of jobs that NASA engineers and managers are performing," added Col. Kuhlman. "The group's people have participated directly in the assembly, checkout and launch countdown of the Shuttle."

The jobs of the "blue suiters" includes serving as launch complex managers, systems engineers and test directors. In addition, they have been involved with modification of Shuttle support equipment and writing computer programs for use during launch.

Others worked on solving technical problems, such as those associated with the application of the thermal protection system.

"During the other manned missions I was an outsider looking in; now, I'm an insider looking out," said Sergeant Cooper, who has been associated with the Shuttle programme since the first Solid Rocket Booster arrived at KSC in August 1979. The sergeant works directly for NASA's Solid Rocket Booster management, which is responsible for receiving solid rocket motors and associated flight hardware and inspecting, assembling and checking them out.

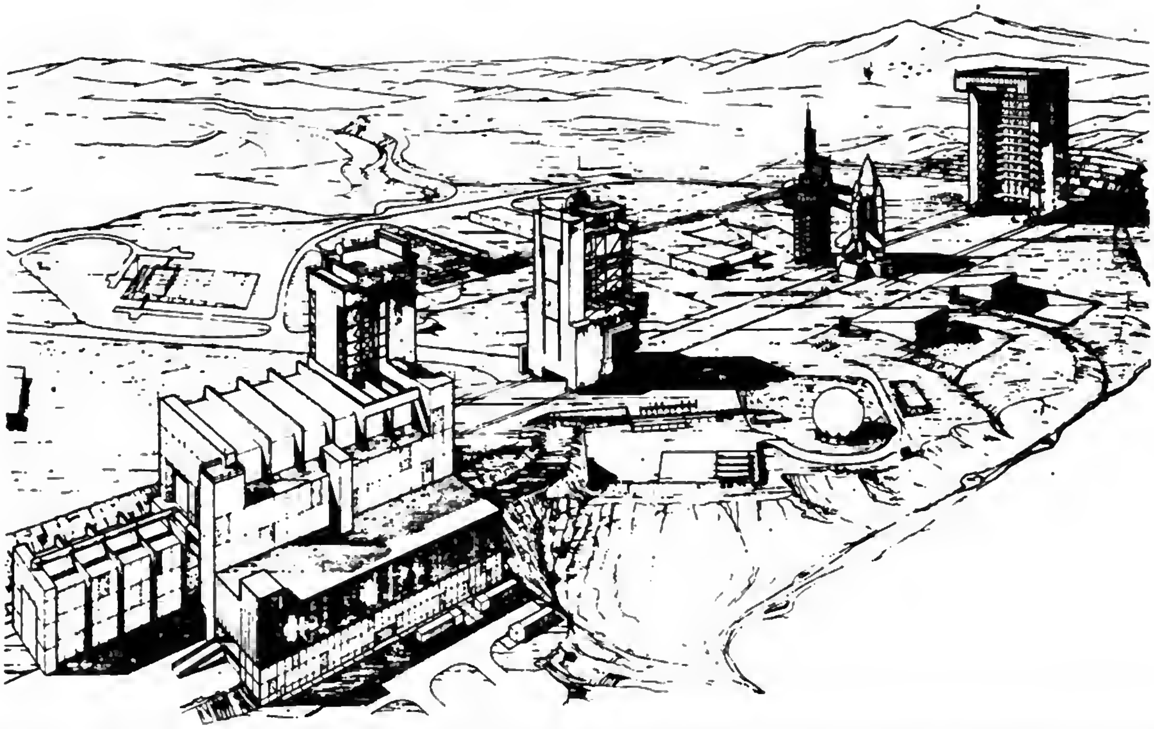
Launch operations

The mode of launch preparation at Vandenberg AFB is radically different from the set-up at the KSC. The Launch Control Centre is 1500 ft from the launch pad as opposed to 3½ miles at the KSC. This closeness of flight support equipment to the blast of launch means that a great deal of effort will be expended in the fields of overpressures and acoustics. Also, the movable Payload Changeout Room tower structure is particularly important in the process of erecting the parallel-staged Shuttle.

According to Brigadier General Mirth "We are going to stack the vehicle out in the wind at Vandenberg. And if you've been out at Vandenberg the wind blows almost all the time at Point Arguello. So we have a very tough design problem lifting that Orbiter and putting it up on the External Tank. We have to lift with the Payload Changeout Room the equivalent of a (Boeing) 747 aircraft underneath a railroad bridge. And you pick up the railroad overpass bridge and pick the entire aircraft and the bridge up. And you move it about 300 feet. And then mate it to the External Tank within a tenth of an inch clearance. A very, very difficult design problem.

"The Mobile Service Tower is one of the things currently existing but we are going to have a good portion of that down and build it up and modify it substantially.

"We did in the early concept phases feel that stacking could be done on the pad without any problem. The topography at Vandenberg really does not lend itself to the construction of the kind of facility that we have at the KSC in the VAB



The Shuttle launch area at Vandenberg. Here, the vehicle elements will be stacked *on the pad* and not in a separate building, as at the Kennedy Space Center.

(Vehicle Assembly Building). We may well wind up with, before we solve the erection problem on the pad, some kind of protective structure around the entire stack. At that time the concept was in the early days (and) everybody thought we could do it and I believe we'll find a way to do it.

"The facilities at Vandenberg will have the capability to process a single vehicle in the Orbiter Maintenance and Check-out Facility (OMCF) and a single vehicle on the pad. Now when we get to the full capability we will have a safing and deservicing facility and we will be able to safe the vehicle and do some preliminary work on it and do some things like take off the OMS (Orbital Maneuvering System) pods and so on in the SDF before it goes into the OMCF. So the sequence when we have the full capability of a full 20 launches per year would be one vehicle in the SDF or the OMCF with another vehicle on the pad.That's the way we handle multiple vehicles."

DoD Future Roles

The future holds the potential of a variety of missions and concepts for DOD Shuttle usage. After two years of work, an Air Force industrial military panel examining the utility of military man in space concluded that DOD may want to use the Shuttle to assemble large structures in space, test military space subsystems, repair spacecraft and act as a command post during contingencies.

Former Air Force Secretary Hans Mark told the House Appropriations Defense Subcommittee that the US would need "a much more capable surveillance system, probably with human presence, so that we do not rely on machines alone and so that the information includes judgements by people the President directly trusts."

Lt. Gen. Thomas Stafford discussed the possible evolution of such an orbital military command post:

"The main thing that space will evolve is to start with a command and control communications (in orbit). Today we have our operational command authorities, a Boeing 747 and a KC-135 that the SAC Commander has. Down the road, I can see this National Command Authority might be delegated to somebody in space. And if you go into an equatorial orbit you're really out of the radar coverage of any place in the Soviet Union ... The number of men, all you need, is a maximum of four."

Such a command post "could still utilise relay satellites very effectively as far as command and control of all your forces and your resources. So I can see comand, control and communications being the first step as far as the military applications."

Stafford explained that the portion of the DOD budget such a programme would consume would not be a "big chunk".

"You'd put some of the things you have in that 747 now in something like a Spacelab ... back in the payload bay. You'd send it off and keep it there for a long period of time. In a way it would be like the way the Russians have a Salyut space station (in orbit). They leave it there for a long period of time and go up and come back. We'd do the same thing ... So this would be in a low altitude, not over 200 miles. I'll predict this is going to happen and that we are going to have a National Command Authority like we have a 747 and we'll have it in space."

According to Lt. Gen. Richard C. Henry, Commander of Space Division, "The military man in space is not a part of our (the Air Force) 20-year heritage because we have not needed him for the missions at hand and we have found ways to do without him. Whether he will be a key element in some future military system remains to be seen. With the Shuttle he might be; without Shuttle he certainly would not be (needed).

"Perhaps the greatest challenge lies in the planning we must do in order to use the Shuttle wisely."

Acknowledgments

The author would like to express his gratitude to Lt. Gen. Richard C. Henry, Maj. Gen. Kulpa, Jr., Brig. Gen. Ralph H. Jacobson, Brig. Gen. Joseph D. Mirth, Brig. Gen. William T. Twinting and Col. C. Kuhlman for their kind cooperation.

SATELLITE DIGEST – 154

Robert D. Christy
Continued from the April issue

A monthly listing of satellite and spacecraft launches, compiled from open sources.

The heading to each launch gives the name of the satellite or craft, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes, except where marked with an asterisk, where the time is to the precise minute as announced by the launching agency.

COSMOS 1328 1981-117A, 12987

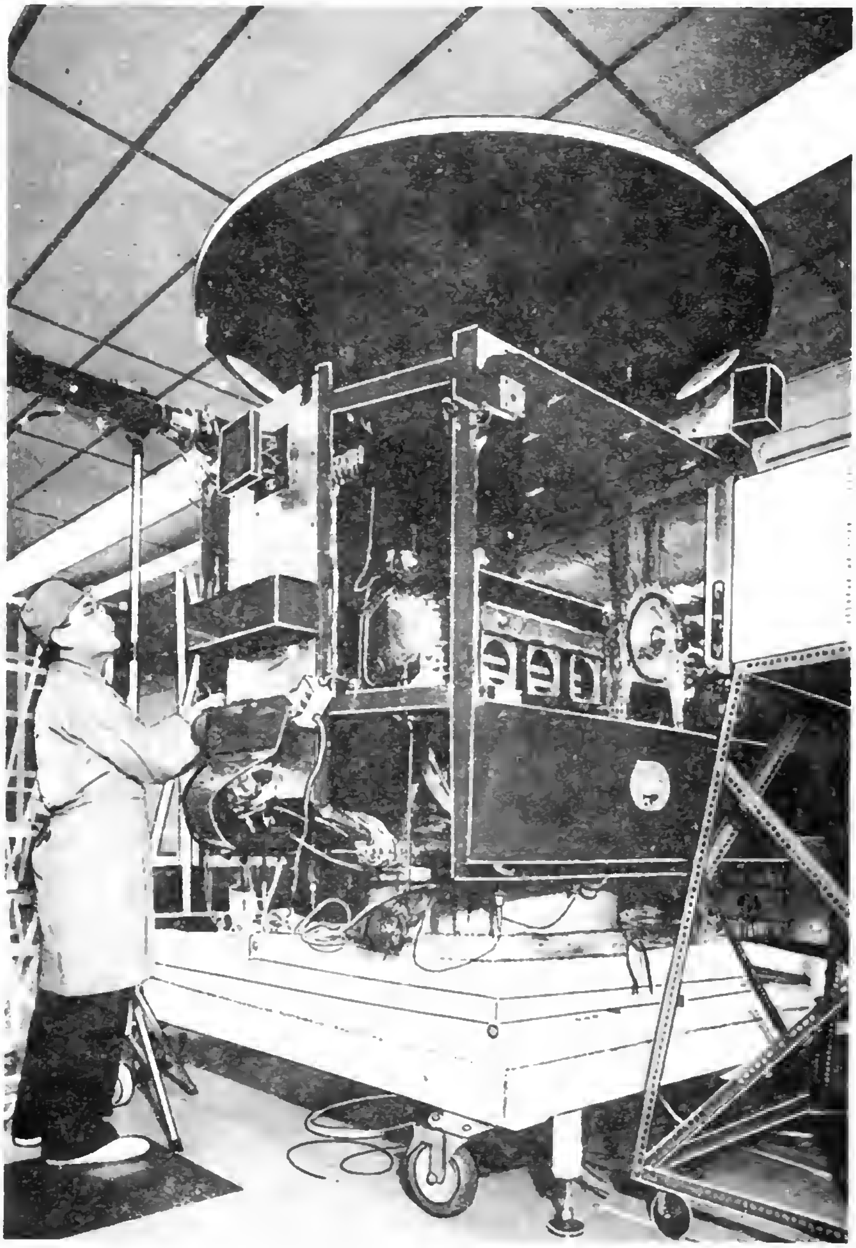
Launched: 1149, 3 Dec 1981 from Plesetsk by F vehicle.
Spacecraft data: Not available but the mass is possibly in the region of 2 tonnes.
Mission: Probably military reconnaissance, the orbit chosen is similar to those of the two oceanographic satellites - Cosmos 1076 (1979-11A) and Cosmos 1151 (1980-5A). The previous launch of this type of satellite was Cosmos 1300 (1981-82A). The orbital plane of the new satellite was 44 degrees to the east of Cosmos 1300 at the time of launch which suggests the possibility of a system being set up with a number of operating satellites at 45 degree plane separations.
Orbit: 636 x 664 km, 97.77 min, 82.53 degrees.

COSMOS 1329 1981-118A, 12989

Launched: 0950, 4 Dec 1981 from Tyuratam by A-2.
Spacecraft data: Possibly based on Vostok manned spacecraft with spherical re-entry module, instrument unit and a cylindrical, supplementary payload at the forward end. Length about 6 m, max diameter about 2.4 m, mass around 6000 kg.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: Initially, 233 x 261 km, 89.45 min, 65.02 degrees which decayed to 227 x 253 km by the eighth day of the flight. A series of small manoeuvres after this resulted in a higher orbit of 231 x 288 km, 89.71 min on 15 Dec.

INTELSAT 5 (F3) 1981-119A, 12994

Launched: 2330, 15 Dec 1981 from the NASA Kennedy Space Center by Atlas Centaur.
Spacecraft data: The Intelsat 5 vehicle is a box with an Earth pointing antenna array, power is supplied by a 16 m span solar array. It is 3-axis stabilised while in geostationary orbit, though during transfer orbit manoevures spin stabilisation is used. The vehicle is built up of three basic units – a support system module for spacecraft housekeeping, the communications package, and the antenna module. It has been designed specifically to fit three types of launch vehicle – Atlas Centaur, the Shuttle or Ariane. The current flight is intended to be the last using the Atlas Centaur. In addigion to the equipment needed to sustain orbital operations, the support system module contains a solid propellant apogee boost motor which took the satellite from its transfer orbit to the geostationary one. The mass of the vehicle at launch was 1870 kg, which was reduced by 863 kg as a result of the apogee motor firing. A further 200 kg reduction will occur as attitude control fuel is used.
Mission: To provide radio communications through 12,000 two-way telephone channels and two colour television channels using frequencies of 4-6 GHz (wide area coverage) and 11-12 GHz (spot beam). The satellite is owned by the 106 nation International Telecommunications Satellite Organisation which has established a system of nearly 200 ground stations around the world. Using these and the satellites, the organisation carries around 60 per cent of trans-Atlantic and trans-Pacific communications.
Orbit: Injected into a 165 x 35940 km, 633 min, 23.6 degree transfer orbit, the apogee boost motor changed the orbit to a 1440 min, equatorial drift one. The satellite was later stabilised above 15 degrees east longitude for systems checkout.



Technicians check the optical alignment of the infra-red Earth sensor on the first flight model of the MARECS maritime communications satellite launched by Ariane on 20 December 1981. The sensor ensures that the spacecraft antennae remain pointing accurately at the Earth. The second MARECS is due for launch this month.

British Aerospace

There are now three INTELSAT 5 communications satellites in orbit.

Aerospatiale

UPDATES:

ISKRA (1981-65A) was de-orbited on 7 Oct 1981 after 89 days.

The following satellites have decayed:

Designation	Name	Date	Lifetime (days)
1962 zeta 1	OSO 1	1981 Sep 13	7155
1963-53A	Explorer 19	1981 May 10	6352
1965-81A	OGO 2	1981 Sep 17	5817
1968-66A	Explorer 39	1981 Jun 22	4701
1971-69A	Cosmos 434	1981 Aug 23	3664
1972-23A	Cosmos 482	1981 May 5	3322
1975-107A	Explorer 55	1981 Jun 10	2029
1976-89A	TIP 3	1981 May 30	1732
1978-99C	Magion	1981 Sep 11	1053
1979-10A	Cosmos 1075	1981 Oct 19	984
1980-21A	Cosmos 1167	1981 Oct 1	566
1980-43A	NOAA B	1981 May 3	339
1980-62A	Rohini 1	1981 May 20	306
1981-51A	Rohini 2	1981 Jun 8	8

RADIO 3-8 1981-120A-F, 12997-13002

Launched: 1059, 17 Dec 1981 from Plesetsk by C-1.
Spacecraft data: All six satellites are probably spheroidal or box shaped, around 1 m across and weighing about 40 kg.
Mission: To provide radio amateurs with spaceborne radio links. Each satellite can rebroadcast in the 10 m amateur band (29 MHz) an amateur user's signal transmitted in the 2 m band (145 MHz). Additionally, the satellites Radio 5 and Radio 7 can transmit telemetric data on demand.
Orbits: The lowest orbit is that of Radio 3: 1564 x 1660 km, 118.52 min, 82.96 degrees; and the highest is Radio 8: 1653 x 1682 km, 119.77 min, 82.96 degrees. The satellites were released during the powered phase of the final rocket stage's flight (it reached 1659 x 1680 km, 120.92 min, 82.95 degrees).

COMOS 1330 1981-121A, 13008

Launched: 1151, 19 Dec 1981 from Tyuratam by A-2.
Spacecraft data: As Cosmos 1329.
Mission: Military photo-reconnaissance, recovered after 31 days.
Orbit: Initially 167 x 379 km, 90.00 min, 70.36 degrees, then manoeuvred several times to provide specific coverage of particular target areas. Cosmos 1330 is the first Tyuratam-launched, long life recoverable satellite not to fly at 65 degrees inclination.

MARECS 1 1981-122A, 13010

Launched: 0129*, 20 Dec 1981 from Kourou by Ariane (flight L04).
Spacecraft data: MARECS' shape is a hexagonal prism 2.5 m high and 2.0 m across. Power is provided by two solar panels. The mass at launch was 1006 kg, reducing to 563 kg in geostationary orbit after the apogee motor firing. MARECS, like INTELSAT 5, is of modular construction, though in this case only two modules are used. The service module is a derivative of that designed for ECS (European Communications Satellite) and provides spacecraft housekeeping, support for the two 5.2 m solar panels and three axis stabilisation by the use of momentum wheels. Station keeping is by hydrazine thrusters. The payload module with its attached antenna makes up the second part of the vehicle.
Mission: Ariane flight L04 was the last in the series of launch vehicle tests before Ariane itself goes fully operational. In addition to the MARECS satellite, the vehicle carried the fourth Ariane Technology Capsule (CAT), a Vibration Isolator Device (VID) and a scientific experiment to measure density in the ionospheric plasma surrounding the Earth (THESEE). These last three were left in the geostationary transfer orbit after the MARECS apogee motor firing. The function of CAT was to make in-flight measurements of the conditions affecting the payload from lift off until T+22 minutes when the Ascension Island tracking station lost contact, and to initiate commands to the MARECS separation devices. The VID was designed to protect the MARECS payload from launcher vibration; it will not be needed on operational flights. THESEE was conducted by a Paris youth club and selected for inclusion after a competition. Its electron probe collected density information up to 2000 km height.

MARECS itself was an opportunity payload carried under the Ariane Passenger Experiments (APEX) Programme. Its purpose is to provide high quality voice and data transmission between ships and shore stations. Eventually a global network will come into operation using two MARECS satellites, and channels provided by INTELSAT and COMSTAR satellites. Operations are controlled by the International Maritime Satellite Organisation, which came into being on 1 Feb 1982, taking over from the existing MARISAT organisation.
Orbit: Initially a 220 x 35811 km, 638 min, 10.5 degrees transfer orbit. At the third apogee MARECS was inserted into a 1431 min drift orbit for eventual stabilisation above 26 degrees west longitude on 2 Jan 1982.

MOLNIYA-1(52) 1981-123A, 13013

Launched: 1315, 23 Dec 1981 from Tyuratam by A-2-e.
Spacecraft data: Cylindrical body housing instrumentation and the payload, surmounted by a conical motor section. Power is provided by a "windmill" of six solar panels. Overall length is 3.4 m and the diameter 1.6 m, mass around 1800 kg.
Mission: Replacement for Molniya-1(45). The satellite helps to operate long distance telephone and telegraph radio communications, and the broadcasting of Central television programmes to Orbita receiving stations in the Soviet far north, Siberia, the Soviet far east and central Asia.
Orbit: Initially a low parking orbit and then injected into a highly elliptical one of 481 x 38964 km, 699.4 min, 62.97 degrees. On the 15th orbit it was manoeuvred to 507 x 39842 km, 717.66 min, 62.84 degrees to provide daily repetition of the ground track.

Note: This is the first Tyuratam-launched Molniya since Molniya-1(37) in June 1977.

SPIRIT OF CHRISTMAS PRESENT

More than 50 Committee Members gathered at the Society's HQ on 16 December 1981 to hear reports on our activities and to discuss plans for 1982, an occasion which also provided an opportunity for a Christmas get-together.

The Members began to gather shortly after 6 p.m., most taking refuge in the warm reception room from London's wintry weather. There they were welcomed by the staff with sherries all round, and the chance to admire our long-suffering Christmas tree and decor. The prize exhibit was Jocelyn Arthur's cake, showing the BIS logo in blue and white icing writ large across the top, although a moment of panic had broken out earlier when the white icing began to turn yellow! Cyril Horsford, of the International Liaison Committee, turned up to what was his second social event of the day: the first had occurred earlier when he had had drinks with Her Majesty the Queen after a meeting of the Privy Council!

Moving into the Conference Room, the visitors were welcomed by President Gordon Thompson, who also introduced two Guests of Honour, Counsellor Justin Bloom of the US Embassy (an earlier visit of his to headquarters was described in February's *Spaceflight*'s "Society News" section) and Wally Horwood of Western Glass International. Both were welcomed and invited, as was everyone else, to sign the new Visitor's Book during the course of the evening.

Len Carter, our Executive Secretary, kicked off the proceedings with a brief run-down (perhaps it ought to be run-up) of the Society's activities and announced that our major event for 1982, Space '82, will now be held in the brand new Brighton Conference Centre, where excellent facilities are being placed at our disposal. Brighton Corporation had also agreed to join the Society in sponsoring an evening reception in the internationally famous Regency Pavilion, besides providing support in many other areas. It had become evident, as plans for Space '82 progressed, that the event was fast out-growing its original venue. Brighton has been chosen to give us more "breathing space". The list of personalities who would be participating in Space '82 was growing all the time, Alan Bean (an Apollo Moonwalker), Tom Paine (ex-Administrator of NASA) and Erik Quistgaard (Director-General of ESA) being examples. Space '82 would be the "Opener" as the Society entered its 50th year, and would be an event which every member would want to attend. Our 50th Anniversary itself would be reached on 13 October 1983 – so we were now well into the run-up period.

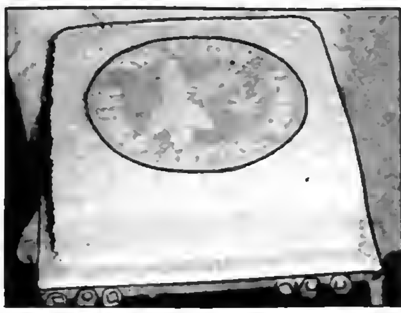
Regarding our HQ, the scope for developing our facilities is enormous. Funds are the problem, of course, so, rather like the boy with his manners, a little has to go a long way. The Council's policy is to identify several areas for completion each year. With a shopping list as long as ours, the remaining work will probably need some time to complete. In our programme for this year, for example, we will acquire a long-needed movie projector for our meetings, along with more basic equipment to enable us to utilise our facilities more intensively.

Gerry Phillips, vice-chairman of the Library Committee, then reported on what has now become one of the Society's most valuable assets. When the Library began, in mid-1979, it consisted simply of a few books and reports, lost among a sea of empty shelves. Now it contains something approaching 8,000 items, conservatively valued at £50,000. We still need about another two years of intensive work to fill in most of the bigger gaps remaining but the Library Committee are making every effort to propel things forward still further until we have the best astronautics library in the UK. The Library's very existence owes a great deal to the enormous goodwill and support demonstrated by many interested individuals, not least the generosity of Arthur C. Clarke who made the whole thing possible, besides the valuable contributions of Library Committee members themselves.

Peter Conchie observed that the work of his Space Technology Committee might seem rather dull at first sight, but that was as it should be. Space technology has now matured to the point where it no longer produces many headlines. His Committee was allocating major effort to the study of space transportation systems because these hold the key to the future establishment of large space platforms, space stations, communications centres, solar power satellites, etc. A one-day symposium on this subject was held in 1981 and another is scheduled for 20 April 1982 (see "Notices of Meetings" for latest details). Other meetings organised by the STC covered the "Solar Sail Race" (17 November 1981) and "Manned Exploration of the Solar System" (13 January 1982).

Tony Lawton (Vice President) described the Executive Committee's role as one of "policing", although as a friendly policeman, a task made all the more important because of the heavy demands made upon staff time from all sources and the inter-related nature of Committee work nowadays. The Council's aim was to see that all aspects of Society work were co-ordinated and conducted as a fully-integrated whole. The result would be effective teams working together instead of individual unrelated units.

The Executive Committee also has to keep a close eye on the Society's finances and ensure that we undertake a developing and balanced workload, without taking on too much too soon. This year, for example, should see not only the success



Left: Gathering in the reception room for sherry. At left is Peter Conchie of the Space Technology Committee, in the foreground (facing the camera) are Les Shepherd (left) and Tony Lawton of the Council. *Above*: the renowned cake!

Transformation from a gleam in the eye (actually, string on the floor) to a smart new Council Room, suitably equipped with reproduction Sheraton table and Wheatear-style chairs. The match with the decor is very close, though the trouble is being experienced in finding Regency-style fluorescent lights!

of Space '82 but also the publication of another new Society book, provisionally entitled *The Eagle has Wings*.

The Chairman of the International Liaison Committee, Dr. Les. Shepherd, recalled that the Society had been a major force in international astronautics for over 20 years, so much so that many astronautical societies around the world had since modelled themselves on us. We had always acted as an international body and this had given us great strength. The International Liaison Committee was formed three years ago, in its present form, to increase our presence in the international scene. Its work was now being reflected, increasingly, in the publication of news, reports, articles and international activities in both *JBIS* and *Spaceflight*.

Prof. Cerry Groves of the Education Committee praised some of the Society's past work. It had been a primary source of Space education material in the 1950's, though more of an intermediary in the 1960's as more and more material had been originated by space agencies. Now, with the introduction of *Space Education* in 1981, the Society is reaffirming once more that astronautics education is one of its major fields. We have found that the new magazine has opened up so many new opportunities and avenues for us that even those members not in the education field will be certain to find it absorbing. We expect they will do so in such numbers that the new magazine will be able to stand on its own feet and become established as a separate publication in its own right in 1982.

The final presentation in the Conference Room was an update on the Shuttle programme. This took the form of screening a new Shuttle film called "STS-1: Post-Flight Conference" which carried previously unseen footage from the first orbital mission, together with Young and Crippen's own commentary. The audience of hardened space-watchers was clearly impressed. A spontaneous round of applause broke out as *Columbia* touched down in the Californian desert.

A late evening buffet prepared by the staff then received the treatment it deserved, with further discussions going on until late into the night before Committee Members felt sufficiently fortified to face the inhospitable weather again.

A special mention of appreciation must be made to all those members and staff who contributed so much to make the evening so successful.

END OF AN ERA

Demolition of the area around the Society's former offices at 12 Bessborough Gardens is now well under way to make way for a big redevelopment scheme.

When the Society was reformed after the War, it was allowed to use the prestigious address at Albermarle House, Piccadilly. This stemmed from the efforts of Mr. R. C. C. Slazenger, who was interested in the meteorological rocket which members of the Society were planning at that time though, in actual fact, the Society never really had the use of the premises at all. Post sent there had to be collected by the Executive Secretary.

On one occasion, a determined effort was made to use the premises. Members of the Structures Committee decided to meet there and duly turned up. As it happened, they had not allowed for the doorkeeper, who didn't take too kindly to letting them in, or letting them out afterwards. The result was that high-level discussions took place between Mr. Slazenger, a millionaire, on the one hand, and the doorkeeper on the other, the upshot of which was that the Society received a letter setting out the terms of the agreement for opening and closing doors. The letter went into great detail. There was to

Demolition of the Society's old offices began last January. More pictures overpage.

AS IT WAS

This photograph, which has recently come into our possession, shows the Society's Offices (marked with arrow) as they appeared in the late 19th Century, before the advent of the Electric Tram and befóre the road surface was even made up.

Note the complete absence of traffic, the gas lamp standards and the spear-headed cast-iron railings which were characteristic of that time.

This was the era of the horse-drawn tram. These were kept, with stables for the horses, just beyond number 12 on the left hand side i.e. off the picture.

A view of the demolition in progress from the same angle as the picture at left, but from the nearer side of the square.

be a sliding scale of payment depending on whether the door was open and one, two, three or more members came in, and with a special rate if everybody went out again at the same time. The basic cost of letting one member in and the same member out was to be 6d, roughly 50p ($1.00) at present rates.

Needless to say, the Society was far too impecunious to pay 6d per in and out per member so usage of the hallowed address went no further! In fact, the Society moved to the other extreme by shifting itself, lock, stock and barrel to the Executive Secretary's private address at 157 Friary Road, where it remained for quite some time.

When the opportunity of securing 12 Bessborough Gardens first arose, eyebrows were raised at the thought of letting it to a Society with such a peculiar name as our own. The Lessor was not too amused. He required, instead, that the property be let "to a person of quality". The "person of quality" was duly produced, in the form of Arthur C. Clarke!

The Society took occupation, at first, of one L-shaped office on the ground floor (the basement and two upper floors were then let to other tenants). After a decade it was able to take over a similar area on the first floor.

For most of its period of occupation, the front door of "Number 12" stayed wide open from morning till night, as was customary with many offices of that time. Anyone could walk in! Security measures were largely unheard of and then unnecessary. The only vandalism was that the Society's nameplate on the front door was constantly unscrewed and taken by souvenir hunters. To deter them, succeeding nameplates became grottier and grottier – but the battle was finally won only when the nameplate became so disreputable that no one wanted to steal it!

NASA POST FOR BIS FELLOW

Dr. Burt Edelson, a BIS Fellow and one of the speakers at our Space '82 conference in November has been named as NASA Associate Administrator for Space Science and Applications, effective from 14 February.

He succeeds Andrew J. Stofan, who has been in the position in an acting capacity. Stofan will remain as an advisor to Edelson until he moves into another senior management position within NASA.

Edelson will be responsible for all of NASA's Space Science and Applications programmes, as well as the activities of the Jet Propulsion Laboratory at Pasadena in California and the Goddard Space Flight Center in Maryland.

Edelson joined the Communications Satellite Corporation in 1967 as assistant director for COMSAT Laboratories and in 1973 was named director of the Laboratories.

In March 1979 he was elected vice president of COMSAT, and he assumed his present position in September 1980. Prior to joining COMSAT, he served as an engineering officer in the US Navy with assignments on the staff of the National Aeronautics and Space Council at the White House and in the Office of Naval Research.

OBITUARIES

Frederick T. Bevan

With regret we record the death of Frederick Bevan, an Associate Fellow of the Society since 1969.

After working as a design engineer for the Bristol Aeroplane Company, Mr. Bevan emigrated to the United States in 1952 where he was employed by the Lockheed Aircraft Corporation until his retirement in 1973.

We also regret to record the deaths of Prof. Antonio Eula (Fellow), John Mullin (Fellow) and Peter Wharton (Fellow).

SOCIETY MEETINGS

EXPLORATION OF THE SOLAR SYSTEM

The Apollo project took 12 men to the surface of the Moon in flights of extraordinary complexity. Manned space flights since then have been restricted to low Earth orbit, most of them involving the Soviets and their Salyut space stations.

The Apollo debate still goes on. Was it worthwhile? Should the resources have been directed towards more mundane space projects instead of helping one nation to demonstrate technological prowess over another?

One consequence appears to have been the reluctance of space planners in recent years to look further afield than near-Earth projects; manned exploration of the planets has become the poor relation of space travel.

BIS Fellow Bob Parkinson challenged that view in his study of a manned trip to Mars in 1995 (published in November 1981's *Spaceflight*, and in October's *JBIS* in greater detail). He argued that a single manned mission could perform enough science at Mars to outweigh the advantages of a series of unmanned probes (surface rovers, penetrators, orbiters, etc.).

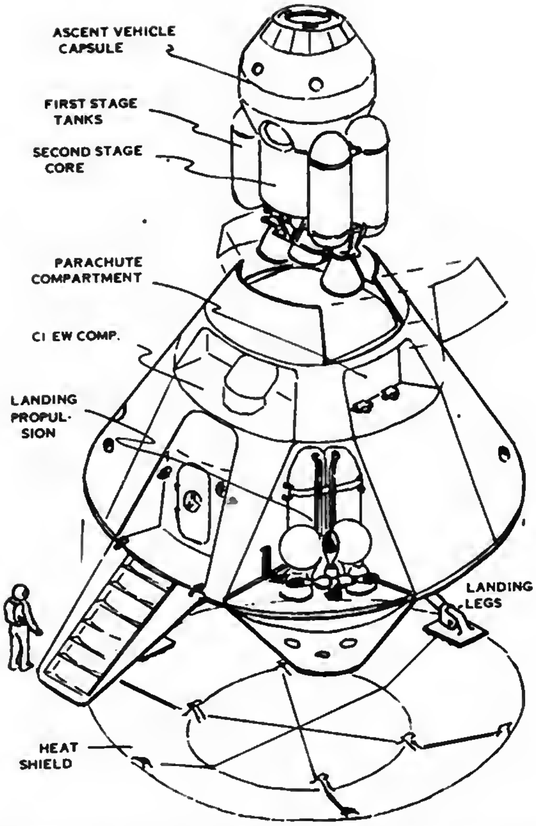
The Society's Space Technology Committee held a meeting on 13 January in the Society's Conference Room to discuss the possibilities and means of Man venturing to the planets, with Dr. Parkinson and Alan Bond presenting their ideas.

Mark Hempsell, the evening's organiser, asked the meeting to consider the possibility of extending Dr. Parkinson's Mars concept to the rest of the inner Solar System. Could we devise a single system for exploring the wide range of targets in our celestial backyard – the Moon, asteroids, Mars and Mercury, for example? One vital aspect to be considered was the overall aim: should it be exploration or exploitation?

On the technical side we have to consider the launch system, the Earth-to-heliocentric orbit boost stage, other propulsion stages, crew habitation units, and planetary excursion modules.

NASA's NERVA nuclear stage was cancelled in 1972, a move which marked the end of US interest in manned planetary flight, as part of the post-Apollo recession. Bob Parkinson decided to look at ways of travelling to Mars using relatively low technology chemical propulsion stages. He assumed that an advanced Shuttle would be available by the mid-1990's, and that a regular low-to-geosynchronous Earth orbit service would exist. The payload would weigh 10 tonnes.

His study concluded that such a mission was possible, with the rough cost estimates coming out at $5,000 million (in 1980 terms). Of that, slightly more than $3,000 million would go



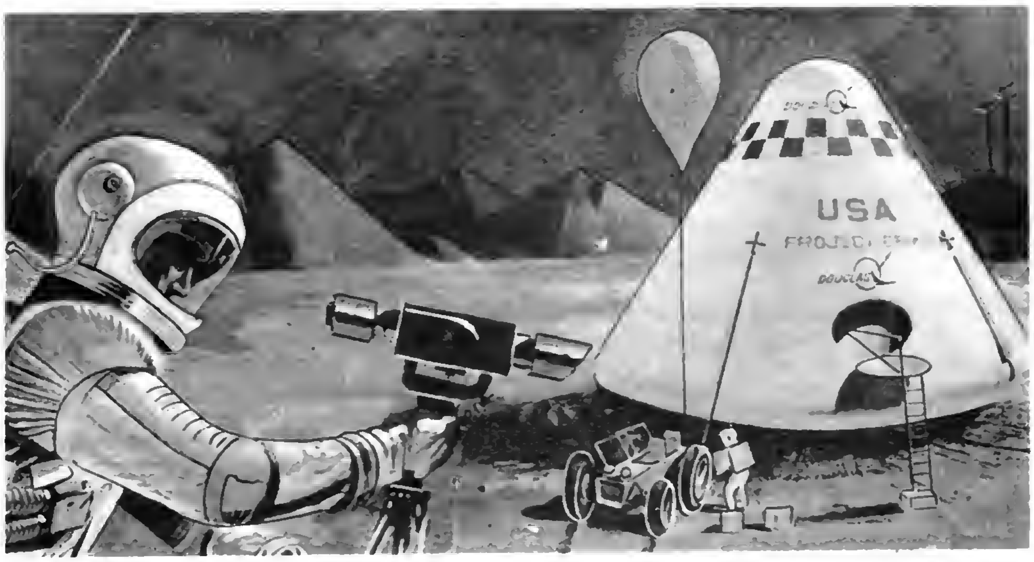
The landing module of Dr. Parkinson's 1995 manned Mars mission (described in detail in the October 1981 issue of *JBIS*)

R. C. Parkinson

towards development. Compare that with the estimated cost of developing a suitable NERVA stage alone: $3,800 million.

Ion propulsion seems unattractive at this stage, and not enough is known about solar sailing. It appears, therefore, that chemical propulsion will stay as the main contender until well into the 21st century.

A look at the required velocity changes for a spacecraft



The "Deimos" Mars mission concept of the 1960's proposed a landing module of 55,000 lb (25,000 kg). Total weight of the vehicle in Earth orbit at the beginning of the mission was 14 million lb (6.36 million kg).

Douglas

travelling to a target in the nearer Solar System illustrates the relative difficulties:

	Approx. 1-way	ΔV(km/s) 2-way	Round-Trip Time (days)
Moon	4	8	10
Mars	5½	12	560
Venus	7	14	550
Mercury	10	19	400
Jupiter	11½	23	1900
Asteroids	?	?	?

These are approximate values, taken relative to low Earth orbit. Of course, there are ways of taking easier routes – remember that Mariner 10 made a swing-by of Venus before reaching Mercury.

If we assume a 10 tonne payload (as was done in the Mars study), together with the availability of 30 and 132 tonne upper stages launchable by a heavy lift version of the Shuttle, then we can create various combinations of craft:

30 t stage → 4.9 km/s
132 t stage → 7.6 km/s (i.e. Moon)
2 x 30 + 132 t stages → 10.9 km/s
2 x 30 + 2 x 132 t stages → 12.9 km/s (i.e. Mars)

Mercury and Jupiter stay well out of reach with these combinations. Mercury holds a special position in the Solar System because it is so close to the Sun. It may be possible to use a "solar heated engine" in cis-Mercurian space, since solar radiation could be used directly to heat liquid hydrogen propellant. In another mission, Jupiter's moons could provide oxygen for the return trip – a large saving in mass on the outward leg.

Alan Bond took more of a "political" view of journeying into the Solar System. While such a programme was not prohibitively expensive, the excesses of Apollo would prove to be a barrier against purely-explorative missions. Rather, he saw a gradual development of space technology until we arrived at the point where we would take the next logical step: travel to the planets.

We might see a 4000 tonne ballistic single-stage-to-orbit launcher carrying an advanced Shuttle Orbiter with 50t of payload. This would allow us to build, first, in low Earth orbit and then extend our operations into geostationery orbit. From there we could return to the Moon and search for profitable resources.

This is an evolutionary, rather than revolutionary, process. Larger and more powerful vehicles would be developed, possibly with a return to nuclear propulsion.

The general consensus by the end of the meeting was that manned exploration of the planets is technically feasible and worthwhile. We migl.t not see a large spaceship on its way to Jupiter in 2001 but if we discover a large alien monolith on the Moon in the next few years, who can tell?

STARS – THE SOURCE OF LIFE

The first of two lectures given by Cambridge astronomers in January was concerned with stellar structure and evolution, particularly from the point of view of the formation of the chemical elements (nucleosynthesis).

Commenting on the relative lack of attention which stars receive these days in comparison with the more exotic astronomical objects, Dr. Charles Whyte began his talk on 20 January in the Society's Conference Room by pointing out that all of the energy sources available to Mankind have been formed by stars in one way or another.

Describing the formation of a star from the collapse of a cloud of gas (primarily hydrogen), he examined three typical cases (with masses of 0.2, 1 and 10 times that of the Sun) by way of illustration.

In lighter stars, the amount of heavier element (beyond helium) synthesis is insignificant. Mass loss from such stars is usually small, so that there is no mechanism by which processed material can be ejected by the star back into the interstellar medium. Stars of solar mass, possessing some convective motion in their outer layers and a stellar wind, can inject some of the heavier elements back into the medium. During its Red Giant phase, as its core collapses, such a star will lose a significant part of its mass to the interstellar medium in the form of an expanding shell of material. (When the Sun becomes a Red Giant, its outer layers will probably engulf the Earth. Interestingly, the Earth could survive this experience due to the low density of a Red Giant's outer layers but the prospects for life would not be so good!).

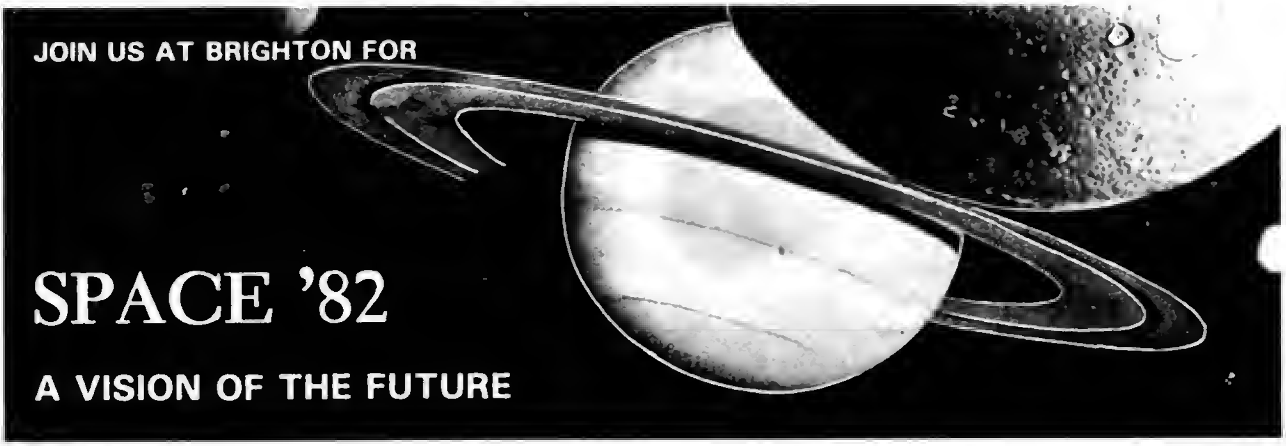
Massive stars, producing the conditions under which advanced nuclear burning can occur, will synthesise the elements up to iron during the latter parts of their fairly short lives. Central collapse in these stars causes them to shed large amounts of matter. By this method, all of the elements up to iron can be introduced into the surrounding medium. For the synthesis of the elements heavier than iron, we have to look at supernovae explosions. The decomposition of iron nuclei into protons and elementary particles in the central region of a massive star can trigger an explosion in which the star is shattered. The heavier elements so produced are then injected into the interstellar medium as debris.

Thus stars, particularly the more massive ones, act as cosmic processing factories. Taking the hydrogen of the interstellar medium, they produce the heavier elements of which most of our part of the Universe, and life itself, is made. The only significant amount of nuclear synthesis which occured independently of stars was the production of helium from hydrogen during the latter stages of the Big Bang.

Dr. Whyte concluded by describing the distribution of Population I, II and III stars (the latter having been formed very early in the history of the Universe) and the relative abundance of the heavy elements in them. He suggested that the search for extra-terrestial life should be directed primarily at regions of the Galaxy abundant in the heavier elements.

Other topics discussed included the binary star model for Nova outbursts which, although generally accepted for many years, has not prevented science-fiction writers from continuing to speculate on the consequences of a solar Nova. Dr. Whyte also predicted that the advent of the Space Telescope will enable us to identify variable stars in the nearest clusters of galaxies, thus dramatically improving our estimates of their distances.

As a final remark he noted that the relative lack of abundance of silicon compared to carbon might decrease the chances of silicon-based life evolving. At this, the Chairman pointed out that a very successful form of silicon-based life was emerging on Earth at the moment – the micro-chip!



Space '82 will provide an excellent opportunity for Members and their guests to meet the people making space history. Top speakers from the world of astronomy and astronautics will present lively views on how Mankind will expand into the Universe and what benefits we can expect.

Erik Quistgaard, Director General of the European Space Agency.

LATE ANNOUNCEMENT
We are pleased to announce that Olof Lundberg, Director General of the newest organisation on the space scene, INMARSAT, will be one of our guest speakers at Space 82.

Tom Paine, a past Administrator of NASA.

The Shuttle provides the path to the exploitation of space. Ex-NASA Administrator Tom Paine and Raefe Shelton of British Aerospace will take on the task of reviewing space industrialisation. Burt Edelson, just appointed as NASA's Associate Administrator for Space Sciences and Applications, will consider that vital topic of "World Space Communications".

Provisional titles for other talks scheduled are:

Patrick Moore	:	The Moon – Our Foothold in Space.
Dr. G. Mueller	:	Space in the 21st Century.
Dr. R. C. Parkinson	:	Manned Settlements on the Moon?
Dr. G. Hunt	:	Exploration of the Solar System.
Capt. R. F. Freitag	:	How NASA Sees the Future.
Reg Turnill	:	Public Eye on Space.
Dr. A. R. Martin	:	The Interstellar Probe.
Prof. M. S. Longair	:	Space Telescope.
E. Quistgaard	:	Space: New Opportunities for Man.
Prof. M. Rees	:	The Universe at our Fingertips.
Ted Mallet	:	Europe in Space.
Dr. W. I. McLaughlin	:	Evolutionary Pathways for Man & Machine.
H. J. P. Arnold	:	Space Kaleidoscope
Dr. P. A. Penzo	:	Deep Space Exploration.
Major P. A. Swan	:	Developing Future Astronauts.
C. R. Turner	:	Our Society – 50 Years Old.

A particularly interesting session will be held on the theme of the 1985/86 return of Halley's comet. Probes to Halley will be launched by Europe, the USSR and Japan in an effort to answer fundamental questions about the early history of the Solar System. Our chairman will be Dr. D. W. Hughes who can be said to have originated the European *Giotto* probe scheme with his paper "The Direct Investigation of Comets by Space Probes" which appeared in the Society's *Journal* in 1977. Dr. R. Reinhard and R. M. Jenkins, responsible for the scientific and engineering aspects of *Giotto*, respectively, will add to our coverage of this major event with overviews of how

A Special Invitation to Provincial and Overseas Members

If you haven't been to a Society meeting before, why not come to Space '82? Your Council and Officers and leading members of committees will all be there to greet you. What better time could there be to come and say "Hello"?

Giotto approaches Halley's Comet in 1986.

the spacecraft will work and what it will do:

Dr. R. Reinhard	:	Giotto: The Exploration of a Comet.
R. M. Jenkins	:	Journey to Halley's Comet.
Dr. D. W. Hughes	:	Halley's Comet: Its History & Future.

Reception

Space '82 participants will be invited to an opening Cocktail Reception in the famous Regency Pavilion as guests of the Society and of Brighton Corporation. It will be a chance for everyone to get to know each other and to mingle with our distinguished Guests and Speakers. Martin Fry, Space '82 organiser, will welcome all to the "weekend" and Len Carter, our Executive Secretary, will invite participants to "Meet the Society". It will be a most interesting evening.

Exhibition

We have access to excellent display facilities and the Society is currently exploring the possibility of mounting an Exhibition. If it can be established on a sufficient scale, it will be open to our Members, free of charge.

Souvenirs

With the approval of a Special Space '82 logo, the Society will be offering a wide range of souvenir items. It is expected that these will also interest those large number of members not able to get to Space '82. For this reason, extra quantities are being prepared which will be on sale to Members, in priority, at specially favourable rates. The souvenirs will include sweatshirts, T-shirts, badges and commemorative envelopes.

Members interested in such items can either purchase these during the Conference or, if not able to attend, write for an order form, enclosing a stamped addressed envelope. Stocks are likely to be limited so early application is advisable.

Accommodation

Brighton presents a wide range of accommodation for visitors, ranging from luxury and splendour to the more homely charms of Guest Houses. We can supply a brochure describing all of the hotels and their facilities. All you have to do is fill in a form and send it to Brighton Corporation, together with a small fee of 75p. They will do the rest, finding accommodation within your price range.

How to Apply

Registration forms are available from the Executive Secretary now. Applicants will receive the latest schedule of events (being updated continuously), a brochure of Brighton's facilities, a form for applying direct to Brighton Corporation for accommodation, and other explanatory material. Participants will also receive a detailed Space '82 brochure on arrival as a special souvenir. It will contain photographs and details of all the Speakers.

Please enclose a 20p stamp with all applications.

OUR GALAXY OF SPEAKERS

Patrick Moore	Astronomer and TV Presenter.
Erik Quistgaard	Director-General, European Space Agency.
T. O. Paine	Former NASA Administrator and President of Northrop Corporation.
M. S. Longair	Astronomer Royal for Scotland.
R. F. Freitag	Deputy Director of Advanced Programs, Office of Space Transportation Systems, NASA
G. E. Hunt	Planetary Scientist; Voyager and Pioneer Principal Investigator.
Reg Turnill	Space Correspondent.
R. J. Jenkins	Giotto Project Manager, British Aerospace.
R. Reinhard	Giotto Project Scientist, ESA.
G. M. Mueller	Former NASA Associate Administrator.
W. I. McLaughlin	Mission Design Manager for the Infrared Astronomical Satellite; Supervisor of the Inner Planets Trajectory and Mission Design Group; Jet Propulsion Laboratory.
E. S. Mallet	Director of Applications Programmes, European Space Agency.
C. R. Turner	Secretary-General, Eurospace.
D. W. Hughes	Planetary Scientist.
H. J. P. Arnold	Director of Space Frontiers Ltd.
R. C. Parkinson	Superintendent of the Propellants, Explosives and Rocket Motor Establishment. Author of "High Road to the Moon".
P. A. Penzo	Planetary Scientist.
P. A. Swan	USAF Major.
B. I. Edelson	NASA Associate Administrator for Space Sciences and Applications.
A. R. Martin	Scientist, co-author of Project Daedalus study.
R. M. B. Shelton	British Aerospace.
M. Rees	Director of the Institute of Astronomy at Cambridge.

CORRESPONDENCE

Doctor Who?

Sir, The note about "Anglo-Dutch Collaboration" in last November's issue (p. 301) was interesting. I believe that the telescopes described will put the British and Dutch Empires at the forefront of astronomy at the beginning of this century. But don't you think that it's a bit unwise to reveal to the world that we have perfected time travel and can move large structures through time?

R. L. HARVEY
Hants

Mr. Harvey is referring to the (incorrect) sentence which read: "The Netherlands is to join SERC in building and exploiting four telescopes to be completed by 1896." Our apologies to the four gentlemen in the picture accompanying the item; our slip made each of them over a hundred years old! – Ed.

What About Us?

Sir, In the January issue of *Spaceflight* I read something which raised my normally placid hackles, but thinking it was merely an uncharacteristic slip of the word-processor I decided to do nothing about it. However, this morning I opened my copy of the February issue, and there it was *again!* In the "Space '82" notice I read "encouraging all our Members, both at home and abroad (and their *WIVES!*) to come and join us."

Now, I am not a rabid feminist, but surely you must be well aware that some B.I.S. members are female and therefore not likely to have wives. May I suggest that future notices refer to "Members and their Spouses", or perhaps "Members and their Companions"?

MIRIAM MASON
Surrey

Your wish is our command! – Ed.

Recovery Times of Cosmos Modules

Sir, After about a month into their respective flights, it was reported that Cosmos 929 and Cosmos 1267 had separated large modules (possibly large enough to be manned on future missions) which were recovered on Soviet soil [1,2]. Although recovery dates have been quoted, the times of the recoveries have not been listed.

The two flights were in orbits inclined at 51.6 degrees and were in the same general altitude range as the manned Soyuz craft. Therefore, it is possible to estimate the landing times of the modules from a comparison with the Soyuz recoveries. Past experience shows that from 1979 to date, manned recoveries have been made on the orbit which crosses the equator passing northbound between longitudes 11 degrees E and 20 degrees E.

When Cosmos 929 was operating, however, the Soyuz craft were being recovered one orbit later than this [3], and if Cosmos 929 followed these early flights, 89 minutes should be added to the times quoted below for that mission to give the corresponding times for the next orbit.

The recovery of the Cosmos 929 module is thought to have taken place between 16–18 August 1977: a consideration of the times of passing over the nominal landing site, and also that the recovery took place before the manoeuvre to the 90.8 minute orbit, rules out 18 August. On 16 August Cosmos 929 crossed the equator northbound at 19.19 GMT (all times here are GMT) over 18.3 degrees E. This suggests a recovery at 19.54 for the object which would already have separated from the Cosmos. On 17 August the corresponding crossing was at 18.56 over 17.7 degrees E. This implies a recovery at 19.31.

Turning to Cosmos 1267, the recovery seems to have been on 24 May 1981, approximately mid-way between the recoveries of Soyuz 40 and Soyuz T-4. On 24 May Cosmos 1267 crossed the equator at 20 degrees E around 12.50, and this suggests a recovery time of 13.25. This estimate can be checked with the Soyuz recoveries, which may have been subject to similar constraints. Soyuz 40 came down on 22 May at 13.58, while Soyuz T-4 came down on 26 May at 12.38. For 24 May, the corresponding landing time would have been 13.18, not taking into account the Cosmos 1267 ground track differing from that of Salyut 6.

To conclude, taking the launch time of Cosmos 929 as 17 July at 09.00 (1977) and that of Cosmos 1267 as 25 April at 02.01 (1981), the lifetimes of the recoverable vehicles are as noted below (in the case of Cosmos 929 one should remember that the landing time may be 89 minutes in error for the reasons already noted):

Kosmos 929	30d 10h 54m	(16 August)
	31d 10h 31m	(17 August)
Kosmos 1267	29d 11h 24m	

I would like to thank Robert D. Christy for copies of the Cosmos 929 Two-Line Elements, and the Goddard Space Flight Center for those of Cosmos 1267.

P. S. CLARK
Twickenham, Middx

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2. *Defense Daily*, 29 May 1981, p. 153.
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Rome, the Sun and Venus

Sir, In the account of the Rome meeting of the IAF (published in February's issue of *Spaceflight*) there was a remark criticising the belief by a large portion of the public that "the Sun revolves round the Earth". May I point out that what revolves round what depends on the reference frame adopted, a matter of definition and convention. A pre-Copernican frame is not wrong, just different, inconvenient and (these days) unusual.

The article on "Terraforming Venus" in the same issue considered ways of modifying the atmosphere, rotation period and some other characteristics of that planet so as to render it hospitable for human life. I wonder if it has occurred to anyone that, just possibly, Venus could have been naturally terraformed long ago, and that its now-excessive carbon dioxide atmosphere might be the result of some processes similar to those we are currently experiencing (in their very early stages) on our own Earth. Venus's combination of much greater surface pressure and much longer rotational period could, in fact, be interdependent results of gradual atmospheric densification over a very long period of time.

BRUCE M. ADKINS
France

The Editor is always interested in receiving items of correspondence, notes, comments, or reviews for possible publication. Items submitted must be kept brief, owing to the limitations of space in our magazine. The Editor reserves the right to shorten or otherwise adapt material to fit, for this reason.

The Building of Civilizations

Sir, I should like to add a few thoughts in response to Ray Ward's letter (*Spaceflight*, November 1981) commenting on my letter which appeared in the June 1981 issue of *Spaceflight* concerning the possibility of extraterrestrial civilizations.

Although other researchers seem to have made the point which I discussed before, none seem to have emphasised it. Sagan, for example, admits that "our technology and our monuments would never have evolved without hands" [1], and Coffey notes that "Competent, manipulative hands and a sophisticated language are essential faculties for a cultural animal" [2].

Obviously to obtain the appropriate anatomical equipment for a technological capability, there would have to have been a long evolution directed by a complex interaction of certain environmental factors. Consequently, it would be naïve to suppose that every intelligent end-product of evolution was capable of developing technology and ultimately becoming technologically advanced. The case of the dolphin should warn us against our naïveté. Mankind, however, is a technological species which is dependent on its technology. In fact, it would be impossible to separate man's evolution from his technology. They have advanced each other.

However, be that as it may, an intelligent organism with an ability to make and use tools is not enough to lead to an advanced technology. There are physical limits to what even the most brainy creature can do even if it has hands (or some alien equivalent). A pyramid or a spaceship would be impossible to construct by a single individual – a great deal of cooperative behaviour is necessary (although one could perhaps imagine a rather large kind of alien, with a lot of "hands" and a very long life-span – surely an exception to the "alien norm"). So for, at least, relatively advanced technology (as represented by our past monumental building civilizations, for example), a species needs to be sociable. While this may be reasonable to assume for an intelligent species, we can apply some of the ideas discussed by Hassan [3] concerning human populations to alien populations to find why there may be problems with this assumption. When an organism emerges as an intelligent species, it will be dependent on the natural environment for the resources it needs. Consequently, the size of individual groups of the alien species (a group comprising individuals living together as a community) will be limited by the resources available within each group's "catchment territory" (i.e., the area over which members of a group are prepared to travel to obtain frequently needed resources such as food), and by the extent of cooperative behaviour required in the procurement of food resources. If no cooperation is needed or useful in obtaining food then the sociable behaviour of the species may be in doubt.

Yet besides having a population that is sociable, innovative and anatomically capable of producing technology, a certain amount of social organisation is necessary. For a long time, social scientists have known that there is a relationship between the size of a group (or related groups in an area) and the degree of its socio-cultural complexity [4]. Certainly, the Space Shuttle, for example, would not have got off the ground without a great amount of organisation, besides cooperation, technological capability and innovation.

I should now like to briefly turn to the topic of fire, the use of which some have regarded as the dividing line between mankind (and man's immediate hominid ancestors) and the rest of the animal kingdom [5]. It seems, however, that the use of fire is just one of many significant innovations of man. The earliest evidence for the use of fire is at the sites of Vértesszöllös in Hungary and Choukoutien in China, both dating to around 500,000 years ago, and both having hominid remains of *Homo erectus* affinity [6]. Tool manufacture on the other hand, which most palaeoanthropologists accept as the distinguishing trait of human beings, goes back much further. The oldest stone tools discovered come from Northern Kenya and date to about 2.6 million years ago [7]. Only man and his immediate ancestors have made and used tools on a regular basis.

From the foregoing it may be seen that the emergence of a technological species may not be as spontaneous as many have supposed. There are many variables to consider, both biological and sociological, even assuming the evolution of intelligence.

DIANE HOLMES
Institute of Archaeology,
London

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5. I. Asimov, *Extraterrestrial Civilizations*, Pan Books, London, 1981 (First published in 1980 by Robson Books Ltd.).
6. B. C. Campbell, *Human Evolution*, Heinemann Educational Books Ltd., London, 1967.
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IR and Optical Astronomy

Sir, Commenting on the item "Infra-Red Spectroscopy" in Space Report last October (p. 256), I would like to state that a carcinotron is a "backward wave oscillator" capable of producing frequencies above 300 CHz (sub-millimetre region). So it is actually the local oscillator of a sub-mm Heterodyne receiver and not a measuring instrument by itself.

Your readers might like to know that Iraq has signed a contract for an (Optical and Radio) astronomical observatory with a Cerman consortium (Krupp/M.A.N./Zeiss) on a turn-key basis, consisting of:

1. A 3.5 m optical telescope by Zeiss to be ready early 1986;

2. A 1.25 m optical telescope by Zeiss to be ready mid-1985;

3. A 30 m radiotelescope by Krupp/MAN capable of operating down to 1 mm wavelength similar to the dish being built on Pico Veleta, Spain, for the Max Plank Institute for Radio Astronomy. Our telescope is to be ready in early 1985.

M. Q. HASSAN
Council of Scientific Research
Astronomy & Space Research Centre
Baghdad, Iraq

SNIPPETS

Beyond Recall

Sir, I have found out that in 86,700 BC the modern Australia was called Lanka by the Indians.

Can you verify the above statement of mine? For this service no payment will be made by me.

C. PACAWY
India

It Gets Better!

Sir, *Spaceflight* continues to improve, and the additional news content is most welcome; the new Satellite Digest feature is also very useful and most welcome.

RECINALD TURNILL
Kent

Sir, Well done, the staff, for doing such a good job during the transfer and reorganisation phase. I only wish that I lived closer.

ALAN WRIGHT
Huddersfield

NOTICES OF MEETINGS

Lecture

Title: **THE STABILITY OF THE SOLAR SYSTEM**
by Prof. A. E. Roy
University of Glasgow

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **7 April 1982**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Symposium

Theme: **SPACE TRANSPORTATION SYSTEMS FOR THE 1990's**
Organised by P. J. Conchie

A one-day meeting to be held in the Society's Conference Room, Society HQ, 27/29 South Lambeth Road, London, SW8 1SZ, on **20 April 1982.**

Registration Forms and copies of the Final Programme are available from the Executive Secretary. Please enclose a reply-paid envelope with request.

Lecture

Title: **THE TURBULENT SUN**
by Dr. C. M. Simnett
University of Birmingham

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **5 May 1982**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Symposium

Theme: **SPACE COMMUNICATIONS**
Organised by K. C. Pike

A one-day meeting to be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **19 May 1982.**

Registration Forms and copies of the Final Programme are available from the Executive Secretary. Please enclose a reply-paid envelope with request.

Technical Forum

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ on **Friday, 4 June 1982**, 6.30–9.00 p.m., and **Saturday, 5 June 1982**, 10.00 a.m. to 12 noon and 1.30–3.30 p.m.

Topic: **THE SOVIET SPACE PROGRAMME**

It is anticipated that papers will be given at the Friday evening and Saturday afternoon sessions, with some Soviet space films being shown during the Saturday morning session.

Offers of papers are invited. Further information may be obtained from the Executive Secretary of the Society. Members with a special interest in the Soviet space programme are invited to attend. A registration fee of £2.00 is payable. Forms are available from the Executive Secretary on request, enclosing a stamped addressed envelope.

37th Annual General Meeting

The 37th Annual General Meeting of the Society will be held in the Kent Room, Caxton Hall, Caxton Street, London SW1 on Saturday **25 September 1982**, commencing 3.00 p.m.

Details of the Agenda will appear in *Spaceflight* in due course.

Nominations are invited for election to the Council. Forms can be obtained from the Executive Secretary. These should be completed and returned not later than 2 July 1982. Should the number of nominations exceed the number of vacancies, election will be by postal ballot. Voting papers will then be prepared and circulated to all members.

33rd IAF Congress

The 33rd Congress of the International Astronautical Federation will be held in Paris, France from **27 September-3 October 1982.**

Theme: **SPACE ACTIVITIES OF THE YEAR 2000**

Members of the Society wishing to present papers are asked to notify Dr. L. R. Shepherd, Chairman of the BIS International Liaison Committee at Society H.Q. as soon as possible. Members wishing to present papers to the IAF Student Conference must submit them through the Society.

Film Show

Theme: **STEPS TO THE MOON – 1**

A series of film programmes to sketch the story of man's Exploration of the Moon. The first will be screened at a meeting to be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **6 October 1982**, 7-8.30 p.m.

The programme will include the following:

(a) Destination Moon — The Story of Project Ranger
(b) Close Up — A Look at Lunar orbiter
(c) Project Apollo: Manned Flight to the Moon
(d) Steps to Saturn
(e) Landing on the Moon

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

First Night

An opportunity for new members of the Society (and interested guests) to meet Members of the Council and Officers of the Society will occur on **13 October 1982**, at the Society's HQ Building, 27/29 South Lambeth Road, London, SW8 1SZ, 7.00-9.00 p.m.

Our first two meetings have proved so popular that a third informal evening has been arranged when members can hear about the History and Activities of the Society, see a space film and have an opportunity for a short guided tour of the Building.

New members, or those who have not previously attended any Society function, who would like to attend are invited to apply in good time, enclosing a reply-paid envelope.

Space Systems Conference

Theme: **THE SPACE TRANSPORTATION SYSTEM**
A Review of its Present Capability and Evolution

A three-day meeting to be held in Washington, D.C. USA on **18–20 October 1982**, sponsored by the AIAA, AAS, NSC, DGLR, JAS and cosponsored by the BIS.

Subject areas to be covered include:

(a) The Space Shuttle Orbiter
(b) Orbital Transfer Vehicles
(c) Reusable vs. Expendable Launch Vehicles
(d) Man's Role in Ground and Flight Operations
(e) User Needs for a Space Truck
(f) The Orbital Facility Applications

BIS Members intending to present papers should, in the first instance, contact the Executive Secretary, 27/29 South Lambeth Road, London, SW8 1SZ. The same applies to Members of the Society who plan to attend the Conference.

Film Show

Theme: **STEPS TO THE MOON – 2**

The second programme in this series will be screened at a meeting to

Continued on back cover

SPACEFLIGHT

Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 27/29 South Lambeth Road, London SW8 1SZ Tel: 01-735 3160

Correspondence and manuscripts intended for publication should be addressed to the Editor, 27/29 South Lambeth Road, London SW8 1SZ.

Opinions in signed articles are those of contributors and do not necessarily reflect the views of the Editor or the Council of the British Interplanetary Society, unless such is expressly stated to be the case.

Continued from inside back cover

be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **27 October 1982**, 7.00-8.30 p.m.

The programme will include the following:

(a) Assignment Shoot the Moon
(b) Apollo/Saturn V Lunar Mission
(c) Debrief Apollo 8
(d) Apollo 9 - The Duet of Spider and Gumdrop
(e) Apollo 10: Green Light for a Lunar Landing

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Film show

Theme: **STEPS TO THE MOON – 3**

The third programme in this series will be screened at a meeting to be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **17 November 1982**, 7.00-8.30 p.m.

The programme will include the following:

(a) Apollo 11 — Eagle Has Landed
(b) Apollo 12 — Pinpoint for Science
(c) Apollo 13 — Houston, We've Got a Problem!
(d) Apollo 14 — Mission to Fra Mauro
(e) Apollo 15 — The Mountains of the Moon

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

1983 TOTAL SOLAR ECLIPSE

Since the 1981 Eclipse Expedition was so successful, the Society is interested in sponsoring a further trip to see the total eclipse of the Sun from Java on 11 June 1983. This will be the longest total eclipse in a decade. The tour will last for 21 days and include full air fare, hotels, meals and other transportation.

Included will be stopovers at Hong Kong, Bangkok, the Isle of Penang, Kuala Lumpur, Singapore and Bali - all sites of astronomical, archeological, historic, artistic and, undoubtedly, photographic interest.

For further information, write direct to:

R.V. Frampton, MS 264-519, Jet Propulsion Laboratory, Pasadena, CA 91109, USA.

OUR SPACE LIBRARY

We are seeking many technical books on astronomy, space research and space technology, and would welcome hearing from members with material they would like to donate to us to help fill the gaps.

Please write to the Executive Secretary first of all, indicating what you are willing to present to us.

The Library will be open to members from 5.30-7.00 p.m. on each of the following dates:

7 Apr. 1982	5 May 1982
4 Jun. 1982	6 Oct. 1982
20 Oct. 1982	27 Oct. 1982
17 Nov. 1982	23 Nov. 1982
1 Dec. 1982	8 Dec. 1982
5 Jan. 1983	2 Feb. 1983

While every effort will be made to adhere to the published programme, the Society cannot be held responsible for any changes made necessary for reasons outside its control.

PLEASE PAY BY DIRECT DEBIT

To speed its accounting procedures, which already involve our staff in substantial work spread over many months, the Society's Council has decided that every member with a UK Bank Account now be invited to remit via the Direct Debit System.

This involves the completion of a very simple form which then has to be sent to the Member's Bank.

The form grants permission to the Bank to remit the appropriate sum on January 1st each year. Members may select, beforehand, the amount which they wish to pay, including whichever of the Society's three publications they wish to select and include a regular donation if they wish.

The amount charged by the Society will represent no more than the Member has already agreed to pay.

From then on the Society will tackle the whole chore of collecting, recording and otherwise dealing with subscriptions. Members may safely ignore the printed reminder notices which are sent out each year and, since the authority which they grant allows for changes in the subscription rates in future years, they have no need to take further action on account of these.

Members may cancel their Direct Debit arrangements at any time. Any sums paid in error can swiftly be recovered immediately afterwards.

All in all, this is a good deal both for Members and for the Society.

The only requirement is to obtain a copy of the simple form, complete it and send it to one's Bank! Forms are now available from the Executive Secretary on request.

N.B. *Bankers Order arrangements will be automatically cancelled on completion of a Direct Debit Authorisation.*

"SPACE EDUCATION"

The Society has already distributed two issues of *Space Education* (July and December 1981). We plan two further issues in 1982, May and September, but now they are available on a separate subscription of £3.00 ($8.00).

Planned articles include: a review of what we can learn about the Earth from observing the motions of satellites; a detailed listing of unmanned space exploration, how space is affecting the way we handle information, plus a model for demonstration polar orbiting satellites.

Space Education is one of the Society's exciting new ventures. Don't miss out, write to the Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Rd., London SW8 1SZ.

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CONTENTS

242 **The Return of Halley's Comet** *M. J. Hendrie*

249 **Safety Aboard the Space Shuttle** *Gerald L. Borrowman*

253 **A Brief History of the Voyager Project: Part 6** *Dr. J. K. Davies*

259 **Space Report**

266 **DISCO – Europe's Solar Astronomical Satellite** *Andrew Thomson*

268 **Towards an International Space Co-operation Agency** *S. K. Hurst*

270 **News from the Cape** *Gordon L. Harris*

272 **Space Communications**

274 **The Manned Orbiting Laboratory: Part 3** *Curtis L. Peebles*

278 **Astronomical News** *Prof. J. S. Griffith*

282 **Satellite Digest – 155** *Robert D. Christy*

283 **Japan's Geostationary Meteorological Satellite System** *Nicholas Steggall*

285 **Society News**

286 **Society Meetings**

287 **Book Reviews**

288 **Correspondence**

MILESTONES

February 1982

18 A two day demonstration countdown test for the Shuttle's third orbital mission begins with astronauts Lousma and Fullerton aboard *Columbia*. The launch team are confident of meeting the scheduled 22 March launch target.

27 A report in *Soviet Weekly* confirms that an Indian will take part in a manned Soviet spaceflight (see "Milestones", *Spaceflight* January 1982, p.1).

28 The Marecs 1 maritime communications satellite, launched by Ariane L04 from Kourou, French Guiana last December, officially takes over from the Marisat satellite as the Atlantic link in the Inmarsat system. The system allows ship/shore worldwide communications. The Marisat craft will be held in a backup capacity and Marecs 2 will be launched towards the end of April to take over the Pacific service.

March 1982

1 A landing capsule from the Venera 13 spacecraft lands on the surface of Venus at 7.5° S and a longitude of 303°, east of the Phoebus area. The capsule survived the 89 atmospheres pressure for about four hours and took a soil sample aboard for analysis. Photographs through red, green and blue filters will allow colour pictures of the surface to be assembled. Venera 14 is expected to reach the planet on 5 March.

2 Pioneer 10, the first spacecraft to fly past Jupiter, completes 10 years in space today. It has travelled more than 6,600 million km and received more than 40,000 commands from Earth. It is presently halfway between the orbits of Uranus and Neptune, still returning data on the far reaches of the Sun's atmosphere. By the end of this decade it will have left the Solar System.

5 Mr. William Whitelaw, the Home Secretary, announces that Britain will have two new TV channels available from Direct Broadcast Satellites by 1986. The BBC will run both channels, one a subscription service with feature films, sporting and cultural events; the other showing more international programmes. British Telecom, British Aerospace and Marconi have already conducted extensive studies. Further channels will be available later.

5 The fourth Intelsat V communications satellite is launched by Atlas Centaur from Cape Canaveral. The satellite, capable of handling 12,000 simultaneous telephone calls, will serve the Indian Ocean region.

5 Venera 14 lands a capsule on Venus at 13.25° S and a longitude of 310.7°, east of Phoebe, on a hill. Colour pictures are returned and soil analysis takes place.

8 NASA declares the extended Viking mission to be a "complete success". The two orbiters and landers arrived at Mars in the summer of 1976 and Viking Lander 1 is still sending back data. Its third phase will extend to 1994, some 18 years after landing.

Owing to the reduced supply of material during the summer months, and because of holidays, etc., combined issues of *Spaceflight* of 48 pp each will appear for July-August and September-October. Members will appreciate the difficulties we face in producing monthly magazines with our small staff. For this reason we have concentrated on maintaining earlier issues at 48 pp, making 480 pp for the year in total.

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1 2

THE RETURN OF HALLEY'S COMET

By M. J. Hendrie

In the past, comets were often considered as bringers of bad tidings, plague and misfortune. Even in this century some strange ideas about them and their possible influence on our lives and destiny have persisted.

Halley's Comet* is accessible to scrutiny about every 75 years. No-one can hope to see it on more than two occasions, and some will not live long enough to see it even once. Between apparitions great advances have taken place in science and astronomy, so that each return yields not only fresh information but observations of a completely new kind. This will be especially so during the coming return in 1986.

Introduction

One of the reasons that Halley's Comet holds a special fascination among those otherwise only casually interested in astronomy is the prediction of the date of return to perihelion. It involves an almost magical skill in the calculation of its position after so long an interval.

Given that comets are interesting in general, why Halley's Comet in particular? Up to the end of 1981, 1,073 comets had been observed well enough for reliable orbits to be calculated. These apparitions relate to 681 different comets, 120 being of short-period (periods of revolution about the Sun of under 200 years). The other comets are moving in larger orbits with periods from several hundred to millions of years. A few have fairly reliable elliptical orbital elements calculated and these are of long period. A few more have hyperbolic orbits and they will leave the Solar System if not further perturbed. But by far the largest group have orbits indistinguishable from a parabola and thus have "infinite" or ill-defined periods of at least several thousand years.

Halley's Comet is much the brightest of the short-period comets and it displays a full range of cometary phenomena, usually found only in the so-called "new" parabolic comets.

These "new" comets are often brighter and more spectacular than Halley, but they arrive unannounced and discovery is seldom more than a few months before perihelion passage. The opportunity to plan a comprehensive observing programme worldwide may not arise. But when an interesting comet is found early enough, plans can be made (as in the case of comet Kohoutek in 1973/74).

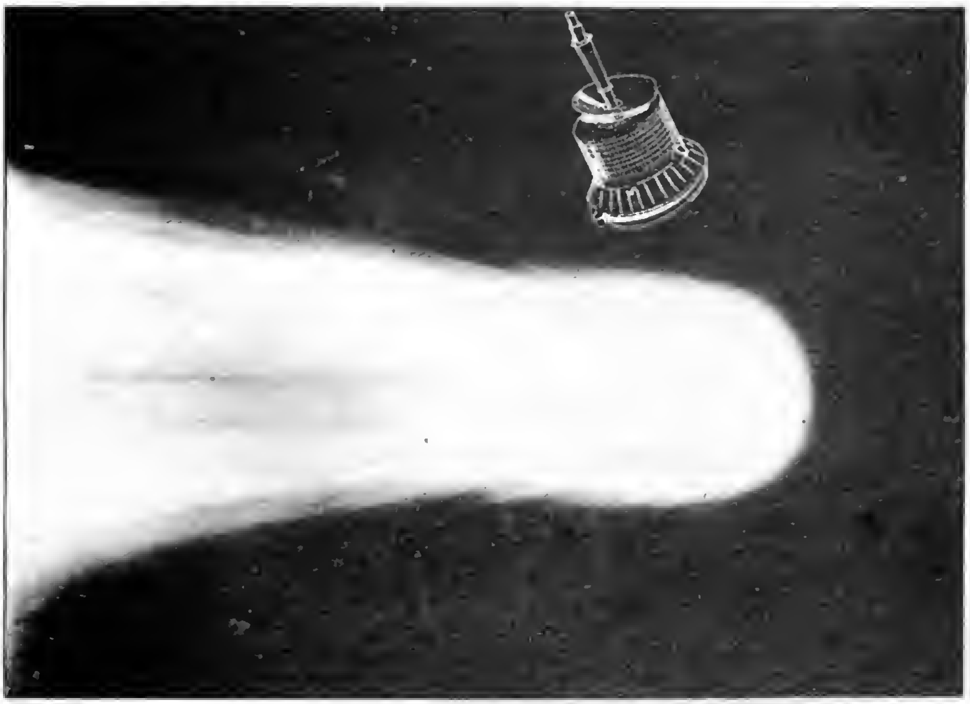
So far, observations from Earth orbit have been limited to satellites designed for other purposes. Even so, important discoveries have been made. These include the giant hydrogen haloes around Tago-Sato-Kosaka and Bennett in 1970, the observations of Kohoutek's anti-tail by the Skylab astronauts and, more recently, a comet apparently plunging into the Sun and observed by the coronagraph on board the P78-1 satellite.

However, to take better advantage of the approach of a large comet, a dedicated comet spacecraft is required. With present technology and financial resources this is a practical proposition only when there is plenty of time for preparation and the orbit of the comet is very well known. Of all the bright comets, only Halley fulfils the requirements.

Cometary Characteristics

Generally, a comet develops as it approaches the Sun. The first sign of rapid brightening (faster than we would expect from reflected sunlight alone) occurs some 3 AU from the Sun, and the first sign of a tail some 2 AU from the Sun. The main

**The 1986 return of Halley's Comet will be described in detail at the Society's Space '82 "weekend" in Brighton on 12-14 November. Information on the comet in general can be found in the July 1981 issue of JBIS in the paper "The Natural History of Halley's Comet" by Dr. William McLaughlin. The concept of sending probes to the comet is described in detail in "The Direct Investigation of Comets by Space Probes" by Dr. David Hughes (JBIS, pp. 3-14, January 1977). The authors of these two important papers will both present talks at Space '82.*



An artist's impression of the European Space Agency's Giotto probe superimposed on a photograph of the 1910 Halley apparition. Giotto will be one of four spacecraft viewing the comet from close quarters.

Edmond Halley, 1656–1742.

emission bands in the comet's head make their appearance around 1.8 AU and the lines due to sodium and iron, if they appear within 0.5 AU.

The seat of the comet's activity and probably the only permanent part is the nucleus, so small that it may never have been directly observed, but not more than 1 to 10 km across. This is thought to be composed of ices and dust particles, and to have a density of about 1g/cc. The nucleus is known to rotate and as it is heated by solar radiation there is an asymmetric release of gas and dust. This can move the comet off the path expected from gravitational forces alone. Many comets fail to satisfy purely gravitational solutions to their orbital equations, and Halley's appears to be no exception.

The escaping gas and dust spreads out to form the head, the outer part of which being known as the coma. Considerable detail can often be seen within the coma, and gas and dust are usually present. Water is believed to be the parent molecule of many of the emissions found in the head and tail.

In the coma, solar radiation ionises molecules and atoms and these are carried away in an anti-solar direction by the solar wind and the magnetic fields moving with it. Matter in the head and tail is therefore always being lost. The dust particles are repelled by light pressure and move away from the head to form the dust tail. This is usually more curved than the gas tail because the forces impart a much lower acceleration (about 100 times less) than those acting on the atoms and molecules. The head is commonly 100,000 km across while tails can be up to a thousand or more times greater. Satellite observations have shown that the hydrogen halo around the head can extend millions of kilometres, making the ultra violet comet head larger than the Sun.

Halley the Man

It is usual for comets to be named after their discoverers but a few are named after people specially associated with them (eg. Encke and Crommelin). Edmond Halley was not the discoverer of the comet that bears his name, although he did observe it in 1682. His vital contribution came from his work on the orbit. But Halley's work on comets, as in other fields such as navigation, the Earth's magnetism, diving and hydrography, was that of a pioneer. He was the first to calculate the orbits of comets with sufficient accuracy to predict the time of return to the Sun. Others such as Cassini may have speculated on the possibility that comets behaved somewhat like the planets, but their calculations, if any were made, were not soundly based.

Halley was born on 29 October 1656 in London of wealthy parents. After attending St. Pauls School he went to Queen's College Oxford in 1673 at the age of 17. He made improvements in the methods of computing planetary orbits which suggested to him the need for measuring the positions of the southern stars to an accuracy comparable with that available for those in the northern hemisphere. He was supported by his father and travelled to St. Helena with a companion. He returned in 1678 and his catalogue of southern stars was published and very well received; he was elected a Fellow of the Royal Society in 1680 at the age of 24.

It was in 1680, while travelling to Europe, that Halley observed the bright comet of that year and, being near Paris, visited Cassini, director of the Paris observatory. From Halley's letters to Robert Hooke it is clear that Cassini discussed comets. Halley mentions Cassini's hypothesis that the comet "performs its revolution in a great circle including the Earth which he will be fixed in about 2 years and a halfe". Halley comments that Hooke may find it difficult to accept Cassini's hypothesis that three appearances were of one and the same comet, but that the idea is remarkable all the same.

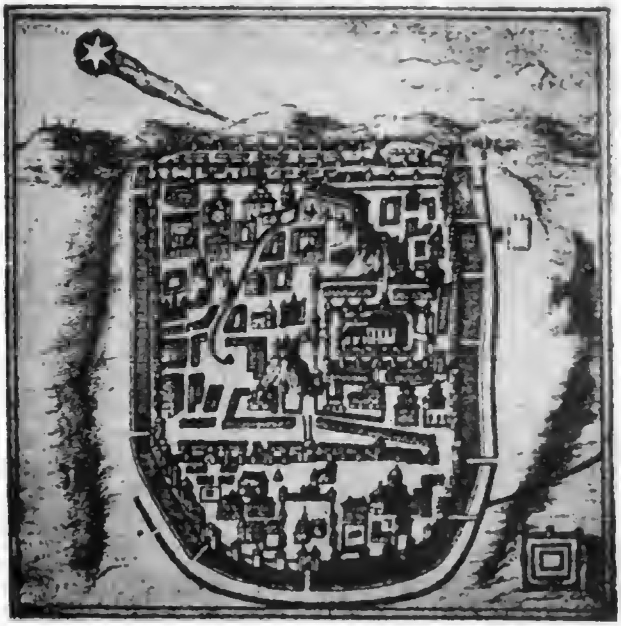
Cassini was wrong, but the idea may well have influenced Halley when he came to study the problem in later years. At the time, Halley tried to represent the comet's path by a constant motion in a straight line (the generally accepted solution). It was only in 1577 that Tycho Brahe had shown that the bright comet of that year was farther away from the Moon. For almost 1,500 years before, many scientists thought comets were within the Earth's atmosphere.

Halley visited Isaac Newton at Cambridge in 1684 and found that he had solved the problem of applying Kepler's three laws of planetary motion to any body in motion about the Sun. Largely through Halley's editorial and financial help, Newton's *Principia* was published in 1687.

The early 1690's saw Halley testing his diving bell at Pagham and advising on the minting of new coinage at the Royal Mint at Chester. In 1698 and 1699 he made voyages to the south Atlantic to chart the magnetic variation and 1701 found him mapping the English Channel. He succeeded Flamsteed as Astronomer Royal in 1714, a post he held until his death in 1742 at the age of 86.

Halley made calculations on the orbits of 24 comets from

A French cartoon illustrates the fears that a comet would hit the Earth in June 1857.



One appearance of Halley, in AD 66, came four years before the fall of Jerusalem. This may be a representation of that apparition.

1337 to 1698 using Newton's theory. He noticed that the elements of the comets of 1531, 1607 and 1682 were very similar. Their periods were not exactly equal and he suggested, correctly, that this might be due to the effects of the larger planets.

In the famous passage in his *Synopsis of the Astronomy of Comets*, Halley continues "You see therefore an agreement of all the elements in these three, which would be next to a miracle if they were three different Comets; or if it was not the approach of the same Comet towards the Sun and the Earth, in the three different revolutions in an Ellipsis around them. Wherefore if according to what we have already said it should return again about the year 1758, candid posterity will not refuse to acknowledge that this was first discovered by an Englishman."

Seneca, a Roman philosopher who lived at the beginning of the Christian Era, wrote "Some day there will arise a man who will demonstrate in what regions the comets take their way; why they journey so far apart from the other planets; what their size, their nature". It took over 1,600 years for the first part of this prophecy to be fulfilled. Their nature may be said to be still somewhat ill-defined, and it took three - Kepler, Newton and Halley - to solve the mystery of their motions.

The Return of 1758/59

As the year 1758 grew near, interest in Halley's prediction of the return of the 1682 comet grew. It was the French astronomer - mathematicians Clairaut and Lalande (assisted by Madame Hortense Lepaute) working for six months from morning to night who completed the onerous work of computing the perturbations for the revolutions from 1607-1682 and 1682-1759. This was necessary in order to determine the month of perihelion passage in 1759.

Clairaut announced that the most probable date would be 13 April 1759 with an uncertainty of a month either way. Despite searches for the comet by professional astronomers, it was an amateur named Palitzch, a farmer living near Dresden, who first saw the comet on Christmas day 1758. On 21 January 1759 it was seen by Messier from the Paris observatory at a magnitude of 6·7.

It was observed until mid-February in evening twilight. Perihelion passage took place on 13 March 1759, just a month before the date predicted by Clairaut. Considering that the masses of the planets Jupiter and Saturn were not too well known, and that Uranus and Neptune had yet to be discovered this was a fine achievement. After perihelion it was recovered by Messier on 1 April near the horizon, in morning twilight, having a tail over 25 degrees long and a nucleus comparable to a star of 0 to 1 magnitude. It was still visible to the naked eye in early June and was last reported on 22 June by Chevalier at Lisbon.

So ended the first predicted return of a comet.

The Apparition of 1835

As early as 1817 the Academy of Sciences at Turin offered a prize for an essay on the perturbations undergone by the comet since 1759. Baron Damoiseau of Paris won by predicting perihelion passage on 4 November 1835. Count Pontecoulant then took up the challenge and working along the same lines as Damoiseau, predicted 12 November 1835. Rosenberger of Halle started his own investigations, feeling that the Frenchmen had not taken their computations far enough back. He included the 1682-1759 revolution. He also took account of the influence of all planets including the Earth, Venus and Mars and predicted 11 November 1835 for perihelion passage. Another German, Lehmann, went back to 1607 and predicted 26 November 1835. As early as December 1834 astronomers were searching for the comet and Sir John Herschel used his 20 ft reflector, then at the Cape.

The first view of the returning comet came on the morning of 6 August 1835 when Dumouchel at Rome found it as a faint misty object near its computed position in Taurus. It was recovered independently by Struve at Dorpat on 20 August. The Dorpat observations showed that Rosenberger's calculated path was less than a third of a degree in error, but the effect was to retard the comet by 5 days so that perihelion passage took place on 16 November and not the 11th as Rosenberger had predicted.

By 23 September the comet was seen with the naked eye by Struve and a tail was first seen on 24 September. By mid-October the tail was some 20 degrees long and readily seen with the naked eye. The comet was lost to view around the time of perihelion passage, passing below the SW horizon soon after the Sun. The comet seems to have lost its tail before running into evening twilight.

In AD 684, Halley's Comet was visible close to the Pleiades.

vnā secisset. sexta
vicensis octaua pa
q pplo constātin
pbie missam latin
q mi aderit. verū esse et sāctū illū sacrificādi
Cometa.
morē. Et q aliter sentiūt a recto et honesto
discedere. Hec ē aūt sexta synodus. q Cy
rilli. Athanasij. Basilij. Gregorij. Dyo
nisij. Hilarij. Ambrosij. Augustini. Hie
ronimi. snīa conclusum ē. duas naturas et
operatōes in xp̄o eē. Explosaq illoꝝ prava
ria q vnicā eē in dn̄o volūtate dicerent. vn
monochelithe vocati sunt. Ea reintegrata fi
dei leticia agatho et romani paucos men
ses sunt gauisi. q pest nūc q̄nta raro alias
p tres meses romam populata est. et ipse
agatho est defunctus.
Stella crinita quā greci Cometē vocāt
indicabat ꝑfecto tot clades q̄ trib' cō
tinuis mēsib' apparuit. Et pluuie magne ac freq̄ntia tonitrua qualia
nūq̄ ātea fuere. vise sunt clesijta i vrbis rome et ytalie excidiū pturasse. ...
...

The AD 684 visit was recorded in the *Nuremberg Chronicle* (pub. 1493) although there is no evidence that the drawing is contemporary.

The comet displayed a range of phenomena in the head and tail and, with the fine telescopes then available, this apparition saw the first real attempts at observing the physical development.

While the tail seems to have reached a maximum length of about 20 degrees on 14 October when the comet was about 1st magnitude, the brightness and length prior to that seems to have been unremarkable, with a tail only a degree or two in length. After perihelion passage, however, the comet seems to have behaved in an unusual way. It was not recorded until 25 January 1836 when Maclear at the Cape saw it with the naked eye as a star of magnitude 2-3. On the following day it was around 2nd magnitude. In the telescope it showed internal structure and a nucleus at times, but very little tail. The comet was still visible to the naked eye in mid-February and was last observed at low altitude in May 1836 when it would have been about magnitude 9 or 10. Maclear last reported seeing it on 5 May 1836.

Bessel made extensive studies of the tail before perihelion. There was of course no photography and no photoelectric devices available, but this apparition, disappointing as it was, did provide the first real studies of the comet itself. Sir John Herschel was at the Cape during the years before and after this apparition, charting the southern skies and continuing his father's work on northern hemisphere objects. He had the 20 ft reflector and a refractor of 4 inches aperture which provided the last views of the departing body. It is interesting to note that this smaller telescope became the finder/guider for the 30 inch Helwan reflector which provided the first photographs at the next apparition in 1910.

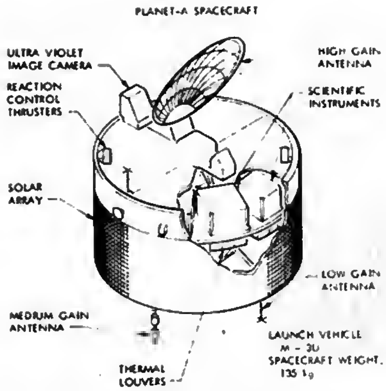
Tracing the Comet's History

Halley himself was the first to seriously attempt to uncover previous visits by his comet. He was successful in identifying the comet of 1456 but he failed to correctly identify earlier returns, not realising how greatly the period might have been modified by the influence of the planets. The comet of 44 BC which appeared after the death of Julius Caesar was thought by Halley to have been his comet, but this is not so, the nearest perihelion passage to that date being 12 BC.

Others have since explored the past history of Halley's Comet, notably Dr. Hind, for many years superintendent of the Nautical Almanac Office, who drew up a list of all apparitions from 12 BC to 1301 AD.

Before the expected reappearance in 1910, Cowell and Crommelin carried out, over a period of some years, computations to test Hind's identifications and predict the arrival in 1910. They found on the whole that Hind's list was remarkably accurate. They extended the dates back to 240 BC, which they considered a certainty, and possibly to 613 BC. However, more recent work by Kiang and by Brady has shown that the identifications before 87 BC are erroneous, although Brady has recently computed to a greater degree of accuracy than previously possible, and has listed dates back to 2647 BC. How many of these appearances can be tied in with historical events remains to be seen, but the uncertainty in the dates of historical events before the first century or so of the Christian Era is probably greater than those of the dates of appearance of the comet. Progress on further identifications could depend less on astronomers and more on historians.

The Japane Halley probe, Planet-A, will carry 10 kg of experiments.



The closest apparition to the birth of Christ was 12 BC Halley's comet therefore does not account for the star of Bethlehem. The next visit was in 66 AD, four years before the fall of Jerusalem, and it may be that this was the comet resembling a sword seen over the city. The apparitions in the years of 141, 218, 295, 374, 451, 530, and 607 were all seen and recorded in China. The apparition of 684 was recorded in the *Nuremberg Chronicle*, but there is no evidence that the sketch was contemporary, the *Chronicle* being published in 1493.

The comet seems to have given some good displays at many of these earlier appearances, and in 837 AD it was widely observed, in April of that year, probably reaching magnitude 0 and have a tail 80 degrees long. Fewer observations are available for 989 AD when perihelion occurred in September.

The year of 1066 bring us to one of the best remembered dates in English history and the first definite contemporary picture of Halley's Comet. This is recorded in the Bayeux Tapestry, an embroidery some 231 ft long and now on view in the Normandy town of Bayeux. It was probably made on the instructions of Bishop Odo of Bayeux for display in the cathedral then being built, and it may have been designed by English artists from Canterbury.

The embroidery depicts the events leading up to the Norman Conquest and the Battle of Hastings, and the comet is seen in the panels where Harold is being shown the visitation. The caption reads "Isti Mirant Stella", which in good Latin should read "Isti Mirantur Stellam". In fairness to the designer the "ur" may be hidden by the scene and the bar or accent over the "a" was a contemporary way of contracting a word ending in "am". The representation of the comet is very good, with most of the features present, if a little stylised. The comet was not visible at the time of the Battle of Hastings since perihelion was in March and the battle did not take place until October of that year.

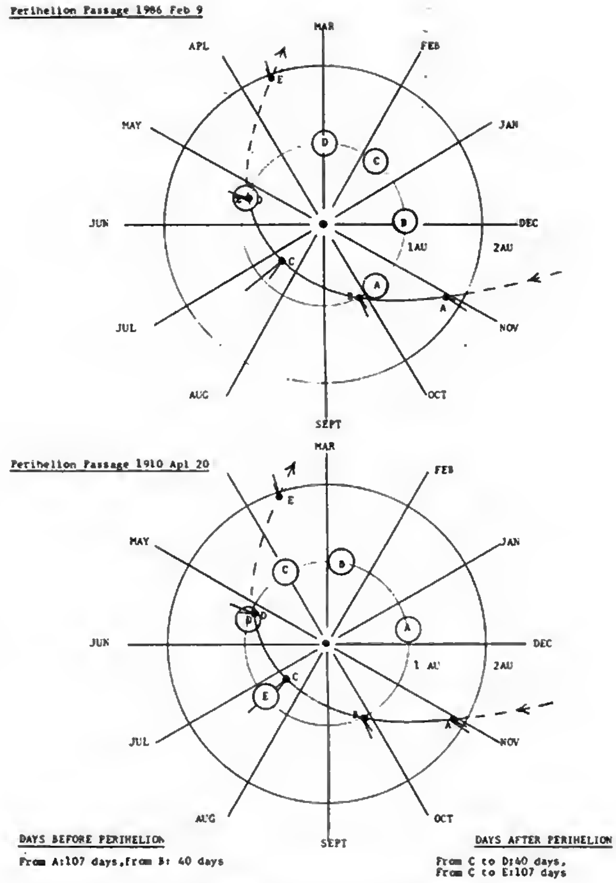
Perihelion passage in 1145 was on the same day as in 1910, so the circumstances were similar. Chinese records mention a tail up to 90 degrees long, or 40 "fuss". In 1222 it was described as having a head half the size of the Moon and making the Moon look dead by comparison. It must have been a splendid sight and it may be that it has become fainter in recent times.

The apparition of 1301 was commemorated by Giotto in his

Month of perihelion passage -86 (87 BC) to AD 1986.

January	February	March	April	May	June
	1986		1910		
		1759			1456
			1145		
		1066			
	837			760	
		607			451
	374		295	218	
66		141			

July	August	September	October	November	December
				1835	
		1682	1607		
	1531			1378	
			1301		
		1222			
		989			
912		684			
		530			
			- 11		
	- 86				



The comet and Earth positions for the 1910 and 1986 passages.

painting "The Adoration of the Magi". The November 1378, and the June 1456 (the latter being one of the most favourable apparitions with regard to perihelion passage) were well observed. That of August 1531 was less favourable. In 1607 the comet came to perihelion in October and was observed by Kepler and Longomontanus, and seems to have reached about 1st magnitude.

In 1682 the comet was discovered in Paris by Picard and La Hire with the naked eye, and later by Flamsteed or his assistant at Greenwich, in late August. The comet had a tail of 30 degrees but it was considerably foreshortened. It was this apparition that Halley himself saw. Thereafter it has come to perihelion only three times, in 1759, 1835 and 1910. We now await 1986.

Before looking at what preparations are being made to receive it on this next visit, we will take a closer look at the display of 1910.

The Appearance of 1910

During the past 900 years between the 1066 and 1986 apparitions, the comet's orbit has not changed to any great extent. The inclination decreased by less than a degree, while the argument of perihelion increased by a little more than 9 degrees and the longitude of the ascending node by a little more than 11 degrees. We can assume, therefore, the relation between the comet's and Earth's orbits to be constant. The comets position in the sky depended on where the Earth was in its orbit and, as the orbit is the same each year, we are left with the date at which the comet comes to perihelion the only variable (to a first approximation).

A convenient way of showing this is to draw the Earth's orbit with that of the comet's projected onto it. Since the inclination of the two planes is only 18 degrees we shall not be too far out if we also ignore the effects of projecting the ellipse onto the plane of the Ecliptic. Then the position of the comet at varying numbers of days before and after perihelion can be drawn in (these positions will not change materially between apparitions either). In the diagrams A=107 days, B=40 days (both before perihelion, represented by C), D=40 days and E=107 days after perihelion passage. We can then mark in the positions of the Earth corresponding to these dates for any apparition. Only a fairly short arc of about 5 months in 75 years is north of the Earth's orbit. When the comet is a long way from the Earth, the Earth's position makes comparatively little difference to the comet's position in the sky. It is presently in the direction of Gemini between Procyon and Gamma Geminorum. The diagram shows that it is always in that part of the sky if discovered while fairly distant and faint.

As the comet approaches the Sun, the Earth's motion has a greater and greater effect. Looking at 1910 in more detail, with the comet at A and about 2 AU from the Sun (about 5 January 1910), it was visible in the evening sky and, being north of the ecliptic, was best placed for observation from northern latitudes. By 10 March it was lost in evening twilight. It emerged into morning twilight about mid-April, and the distance from the Earth was rapidly decreasing in early May as it moved out towards the Earth's orbit. A very rare event happened on 18 May as the comet reached conjunction with the Sun and the descending node of its orbit almost simultaneously. This meant that it passed directly in front of the Sun, an event that happens about once every 50,000 years. Over the next two days there was a chance of the Earth passing through the tail but, because of the curvature, this probably did not happen. Thereafter, the comet and Earth were moving almost directly away from each other and the comet was by then well into the southern sky.

Despite a number of earlier attempts, comet Halley was not recovered until 11 September 1909 when Max Wolf at Heidelberg took a 1 hour exposure with the 28 inch reflector at the Konigstuhl Observatory. He had suspected the body to be on a plate taken on 28 August, but wanted to be certain before announcing it. It was subsequently found on plates taken at Helwan on 24 August by Knox-Shaw with the 30 inch reflector, and on plates taken at Greenwich with the 30 inch Thompson reflector on 9 September. It was very close to the positions of Cowell and Crommelin, and the early sightings showed perihelion would fall about three days later than predicted, two days or more being due to non-gravitational factors. At recovery the comet seems to have been about magnitude 16.

The comet generally showed little tail as it moved into the evening sky in the autumn of 1909 and it was not seen with the naked eye until 11 February 1910, by Max Wolf. When

it passed into evening twilight in mid-March it was about magnitude 5 or 6. It reached about magnitude 2.5 at perihelion, and about 1.5 by early May as it approached the Earth. Nothing was seen of it during the transit of the Sun despite good conditions but this was not unexpected. Even if the nucleus had a diameter of 5 miles, it would have subtended an angle of only 1/15 of a second of arc.

Halley produced a better display after perihelion when it was best seen from southern stations, though still quite well-placed for the large observatories in the USA. Many excellent photographs were taken, especially the long runs obtained at Lick Observatory on Mount Hamilton, and from observatories at Cordoba, Hawaii, and Johannesburg. Larger scale plates were taken from Helwan and Mount Wilson (60 inch reflector). These provided almost nightly records for several months. The tail reached a length of 140 degrees according to one report, but this was about the time of the Earth's supposed passage through the tail when parts were very close. At other times a tail length of up to 30 degrees seems more common.

The reports from Cordoba say that in May the comet was a splendid sight, with a tail from the horizon to the zenith. To northern town dwellers it was not really prominent, and the *Memoirs* of the British Astronomical Association report says that the British spring weather in 1910 was even worse than usual. Even so, the comet was well observed and provided material for the study of these bodies in general. Much of it is now being re-analysed in the light of new ideas and in preparation for the return in 1986.

In passing, it is of interest that the 1835 to 1910 revolution is the shortest on record (74.42 yrs), the longest being that of 451-530 AD (79.25 yrs).

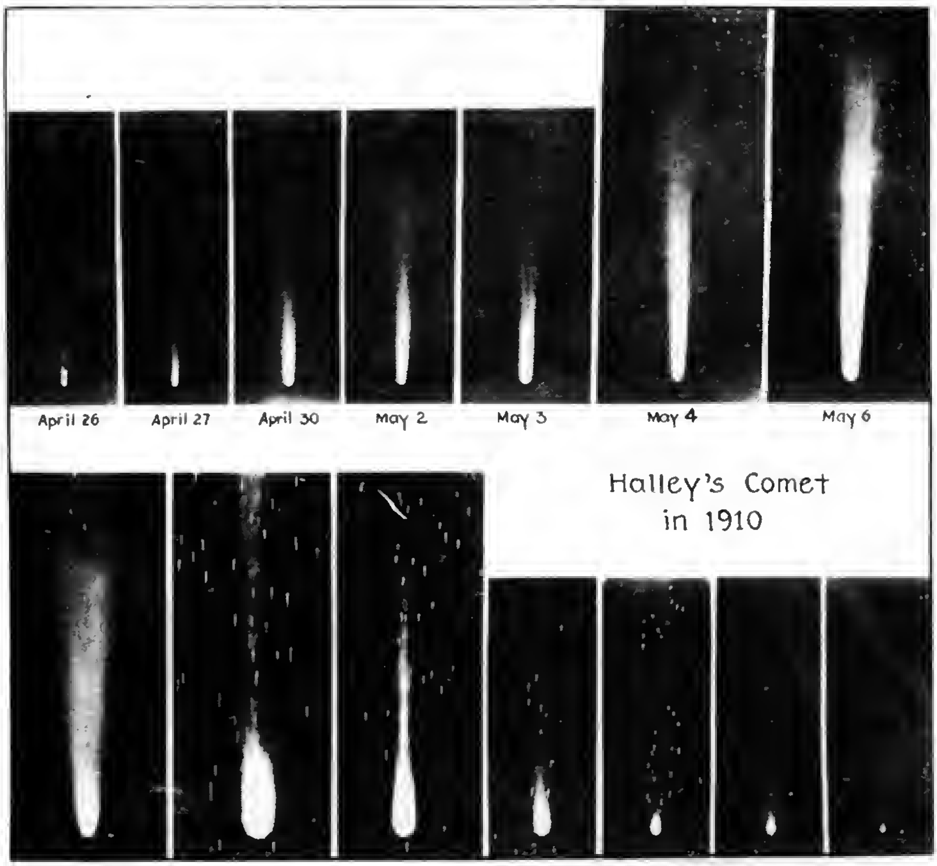
Looking Forward to 1986

The 1986 visit is not a favourable one for observers in the northern hemisphere but it will be much the best observed cometary apparition ever. The USSR, Japan and the European Space Agency plan to send probes to the Comet, and the US Space Telescope should be operational in 1985.

The search for comet Halley started in November 1977 when a 45 minute exposure was made using the 200 inch at Palomar with a Charge-Coupled Device, but without success. At the same time the comet must have been fainter than magnitude 25. It may be recovered at any time but some astronomers believe we may have to wait until 1984. Early recovery is not only of interest physically, but it will also help to refine the orbit which must be accurately known for planning the programmes of observations.

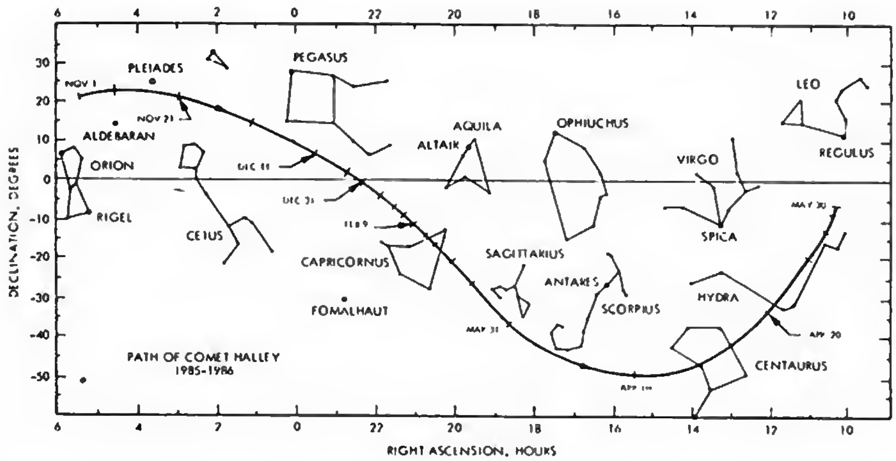
The comet will move from the morning to the evening sky during November 1985 (magnitude 7 or 8) and it may exhibit a tail as it moves through Taurus. Autumn will be the most favourable time for northern observers, with the comet above the horizon all night. The first of two closest approaches to the Earth comes on 27 November when the comet will be 0.62 AU (93 million km) away though still outside the Earth's orbit as it moves southwards below the square of Pegasus. It is unlikely that it will be visible to the naked eye at this time although the tail may develop further. Around mid-January 1986 it will be an evening object only a few degrees from the location of comet Kohoutek in January 1974, and at magnitude 5 the two comets will be equal. But since comet Kohoutek was only 0.8 AU from the Sun and Halley will be 1.4 AU, it is unlikely the tail will be more than 5 degrees long. Halley will disappear into evening twilight on about 24 January while probably no brighter than magnitude 5. Perihelion passage in February puts the comet on the opposite side of the Sun from the Earth – an unfavourable circumstance.

Perihelion passage occurs on 9 February 1986 when the comet will be 0.59 AU (88 million km) from the Sun. It will move farther south after perihelion, reaching 20 degrees elongation from the Sun in the morning sky by 19 February. By then it will be well south in Capricornus and not visible from



Halley's Comet between 26 April and 11 June 1910.

Hale Observatories



The path of Halley's Comet across the sky for November 1985 to May 1986. It will probably be best visible after perihelion, in the southern constellations.

NASA/JPL

the latitude of Britain. The comet is likely to be about magnitude 5, brightening to 4 or more, as it moves north in early April, approaching the Earth within 0.42 AU (63 million km) on 11 April. However, its declination will then be 47 degrees south, placing it high in the sky for southern observers. A tail of 30 or 40 degrees is possible.

Opposition will come in mid-April. After that, the comet becomes an evening object as it moves rapidly north, receeding from both the Earth and Sun, and becoming visible to those in mid-northern latitudes again, fading to about magnitude 7 by the end of May. During June and July it will move very little in the constellation of Sextans, fading to 11^{m} by the end of July and becoming lost in evening twilight once more. Observations will no doubt be possible with large telescopes in late 1986 and probably 1987–1988.

It seems, therefore, that we may not see the comet with the naked eye from the higher northern latitudes, and given the problems of weather and moonlight the prospects are not very good. Observers there cannot expect to see Halley much better than they saw comet Kohoutek in 1974.

From the southern hemisphere the prospects during March and April 1986 are much better and the comet may well be a striking object, since it will be high in the sky and at its brightest. Apparitions do vary so it may provide a better display and become somewhat brighter than predicted. Comet Halley does usually give a better display after perihelion, though 1835 seems to have been a contrary case.

The nucleus is the only permanent part of the comet and it is seldom, if ever, directly seen. But recently, through the work of Fred Whipple and Zdenek Sekanina, the rotation periods of several comets have been determined from a study of the changing directions of well-defined features in the heads (the so-called hoods, parabolic hoods, and jets and fans). The poles of rotation have also been determined in some cases. For Halley, Dr. Whipple finds a rotation period of 10 hours 19 minutes, while Donati's comet, for example, was just over 4.6 hours.

It is very important to observe inner head features as well as tail features, and both require that the comet is kept under observation as continuously as possible, so that the same features can be identified without ambiguity. Inner head features have been best observed visually, but a large telescope and electronic camera obtained some very promising photographs of comet Bennett in 1970 with exposures of a few seconds. No doubt this technique will have been much improved by 1986.

Studies of forces at work in the tail also require short exposures to freeze the motion of identifiable "knots", but here a wide field is also necessary so a fast Schmidt type instrument is most useful. There are all types of spectrographic and spectrophotometric studies requiring large instruments and special equipment: infrared, radio and radar; polarisation and photometric (both visual and photo-electric). High resolution and short wavelength work may be undertaken by the Space Telescope and other orbiting observatories, and no doubt there will be US and USSR astronauts in orbit during the apparition.

Then, of course, there will be the space probes, currently planned by Japan, the USSR and the European Space Agency. ESA's flyby mission is named Giotto after the fourteenth century artist Giotto di Bondone (1267–1337) who, as we have mentioned, included a very good likeness of the 1301 comet in his fresco the "Adoration of the Magi" in the Arena Chapel in Padua. The probe is expected to be launched in July 1985 by an Ariane vehicle. Halley encounter will be in March 1986, four weeks after perihelion, at a heliocentric distance of 0.9 AU with a flyby velocity of 68 km/s. The payload mass will be 53 kg, consisting of eight experiments and allowing a high data transmission rate of 40 kbps during for at least four hours of scientific data during the encounter. Giotto will carry a telescope for imaging the inner coma and nucleus, neutral, ion and dust mass spectrometers, dust impact detectors, an electron/ion plasma analyser and a magnetometer for plasma studies, together with an UV spectrometer for studying the cometary atmosphere.

The high flyby velocity of 68 km/s can be an advantage if coupled with a very high data transfer rate because the instrument background noise is suppressed. It aids the dust impact spectrometer, cometary ions can be separated from those due to impacts, cometary neutrals can be separated from outgassing from the spacecraft, and cometary time scales found in the coma are long compared to the flyby, thus providing a clean spatial view. Impacting dust particles are, of course, more of a problem and a double bumper shield will be provided which, it is hoped, will protect the probe to within a few hundred kilometres of the nucleus.

The camera should provide a resolution down to 50 m. The probe will spin at 15 rpm with the Ritchey-Crétien system feeding a Charge Coupled Device which will enable a line of image to be transmitted at each rotation. "Colour" pictures can be built up without the need for mechanical filters. Maximum resolution will yield an 800×800 pixel image.

In view of the hazard of impacting dust particles all data will be sent back to Earth in real time, and there will be no data storage on board. The trajectory will lie largely within the Earth's orbit, meeting the comet almost head-on on 13 March at a distance of 0.89 AU from the Sun and 0.98 AU from the Earth. The comet will be a morning object in the southern hemisphere at that time, but should be well placed for the large observatories in South America, Australia, South Africa, the Hawaiian Islands and Teneriffe. Most of these were not established in 1910.

SAFETY ABOARD THE SPACE SHUTTLE

By Gerald L. Borrowman

What would happen to the astronauts if the Shuttle Orbiter went out of control or had to make an emergency landing? How would they escape from the launch pad if an explosion threatened? The author examines the safety and rescue procedures of the Shuttle system.

The Ejection System

For the first four Orbital Flight Tests of the Space Shuttle an escape system provides ejection capability for the commander and pilot up to 80,000 ft (24,000 m). The system consists of the seats, ejection/escape panels, energy transmission and system sequencing, and panel jettison actuation for non-ejection ground entrance and exit.

Directly above the forward seats are the overhead ejection panels. These panels consist of crushable honeycombe pads for shock attenuation and thrusters to propel them clear of the Orbiter.

The ejection seats take the astronauts away from the Orbiter and sustain and stabilise the motion of the escape for Orbiter clearance, stabilisation/deceleration, occupier separation, recovery, and activation of the survival systems. The design called upon hardware of the SR-71 high-altitude reconnaissance aircraft.

Upon completion of the Orbital Flight Tests later this year the seats and their supporting elements (such as the overhead panels) will be replaced by operational equipment.

"It's not really designed for pad (emergency) use, "according to Larry Rayburn, a NASA pyrotechnic systems engineer, "but it could be ... it's a marginal thing. The 'chutes might have pad-ejection capability, but I wouldn't want to try it. If there's no other way out, you've got to give it a whirl."

Pyrotechnic experts at the Kennedy Space Center express confidence that the system will work under more "normal circumstances", such as during a difficult landing.

"All of these ejection devices are dangerous, and we don't really want to see them used just to see whether it will work," Rayburn said. "But it's been tested on mockups and we feel confident about it."

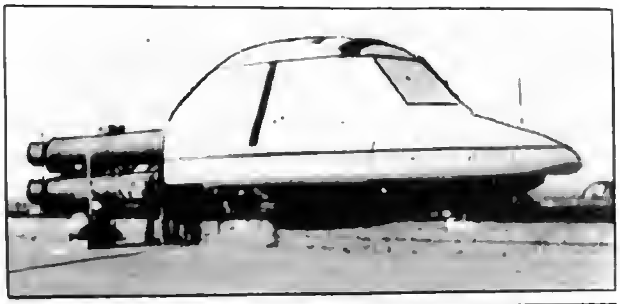
The Orbiter ejection seat can operate in two flight regimes:

1. For ejection above 15,000 ft (4,500 m): the seat descends on a drogue parachute to 15,000 ft where separation and personal parachute deployment occurs.
2. For ejections below 15,000 ft: the personal parachute is deployed 1.6 seconds after escape propulsion ignition.

The seat is stabilised in both methods by means of a 76 in. diameter (1.93 m) drogue parachute located in the head rest which is deployed by a motor as soon as the seat leaves the Orbiter cockpit. The drogue not only stabilises the seat during the ejection phase, but also provides stability for the long descent from high altitude. It also provides rapid, controlled deceleration to allow quick deployment of the personal parachute for low altitude ejections. The low-altitude capabilities of the ejection seat are improved by a mortar-deployed personal parachute.

The escape system allows safe recovery for ejections from the launch pad even before lift off by using:

1. A high-impulse rocket to produce maximum ground clearance,
2. A high-energy seat separator which also arms the personal parachute,
3. The fast system timing,
4. The mortar-deployed, quick-opening parachute.



Testing the ejection system of the Shuttle. Instrumented dummies were shot out of a cabin mockup moving at 500 mph at the Holloman Air Force Base in New Mexico.
NASA

The escape system has three modes of operations: primary, secondary, and manual egress. The primary mode results in automatic panel jettison and the ejection of both seats. The secondary mode includes ejection of *each* seat. The manual egress mode does not involve ejection, but provides the crewman with a quick method of disengaging himself from seat restraints for emergency ground egress.

The Ejection Suit

The Ejection Escape Suit (EES) is an "off-the-shelf" US Air Force full pressure suit (model S1030A) modified by adding anti-g protection (for the re-entry phase) and medical monitoring.

The EES consists of a torso assembly, a helmet with a

laminated shell, full pressure gloves, retainer assembly, urine collection system, anti-g protection and biomedical monitoring equipment. It has separate breathing and ventilation gas inlets, each with indepedent plumbing and ducting systems.

The helmet assembly is fitted with a movable visor and sunshade, communications gear, cushion liner, feeding/drinking port, anti-suffocation valve, face barrier, fitting adjustments system, breathing oxygen system and a neck rotation bearing/disconnect ring which mates with the full pressure coverall.

A face barrier inside the helmet shell is made up of sponge, coated cloth, a neoprene face seal and an aluminium frame. This barrier encloses the mouth-nose cavity of the helmet and maintains the positive breathing pressure supplied by the breathing regulator, thus insuring against contamination of the 100 percent oxygen breathing gas with the coverall ventilation air. A spring-loaded exhalation valve is included so that exhaust gases can pass from the face cavity to the rear compartment.

The full pressure coverall assembly is a multi-layer integral unit which covers the torso, neck, arms and legs (including the feet).

A retainer, made of Fypro material, contains the integrated parachute harness and flotation system. It is donned separately from, and worn over, the coverall assembly, covering only the torso area.

A torso harness provides the connection with the parachute rigging, and consists of nylon webbing with adjustment buckles and "D" rings to provide single-point adjustment at the chest. A quick-release buckle is included at the chest to simplify donning and removal. It is designed as an integral but removeable part of the retainer assembly.

A dual cell inflatable garment of coated nylon allows for flotation in water. Each cell is equipped with an automatic/manual inflation assembly, which includes a carbon dioxide cylinder. The garment is attached to the exterior of the retainer assembly, outside of the torso assembly and stored under flaps on the retainer which open automatically on inflation. Manual inflation is accomplished via lanyards routed to the front of the retainer. Automatic inflation occurs immediately on water immersion and a mouth inflation hose is provided for both cells as a safety feature.

The suit ventilation hose is connected to the ventilation system of the Orbiter and is automatically disconnected when the escape system fires.

The EES is capable of protecting the crewmen during high-speed (Mach 2.7 maximum) and high-altitude (80,000 ft/24,000 m maximum) escape.

The primary escape system is activated when the D-ring, located on the forward part of the seat between the occupier's legs, is pulled. All events thereafter are fully automatic and, although backups are available, require no further action by the crew men. The D-ring also serves as a handhold to prevent the arms from flailing during ejection. It is automatically severed to release it from the seat at separation.

The ballistic rocket/catapult is a single unit consisting of a cartridge for initial propulsion and a rocket motor for sustained propulsion during separation from the Orbiter. When ignited, the catapult motor burns for about one second and develops a total thrust of 6900 lbf (30,705 N).

Rollers on the ejection seat run along guide rails. Other elements are slide blocks, a support structure to install the rails in the vehicle, and stowage attachments for crew equipment. The angle causes the seat to be ejected 15 degrees towards the rear. The forward edge of the inboard rail for each seat has been shortened to produce a rotation during ejection for a greater separation between the two astronauts.

Once ejected, the seat holds the astronaut with a ballistic, hot gas-powered, inertial lock-type shoulder harness system located behind the headrest. The system consists of a spring-loaded reel, inertial locking mechanism, a gas generator, and shoulder harness attached to the crewman's integrated harness.

John Young, in training for the STS-1 mission in April 1981, rides in the M113 escape van. The van is used to drive astronauts and ground crews to safety after they have descended from the top of the service structure on the slide wires.

NASA

A lever on the left side of the seat manually locks or unlocks the reel. In the manually unlocked mode, the reel is still sensitive to inertial loads and will lock automatically if there is an acceleration which causes the harness to extend rapidly (2 to 3 g's). When the shoulder harness reel gas generator is ballistically fired, the harness straps are wound back to position the occupant for ejection. At the time of man/seat separation, a gas pressure signal causes the reel-locking mechanism to move into "free-spool", permitting the two straps to peel off the spool.

A foot retraction system consists of two cables with an attachment for foot spurs, permitting free movement of both feet for piloting duties. At the time of seat ejection, the foot retraction actuator is gas-fired and pulls in the feet. The cables are cut at the time of seat separation.

A catapult safety valve is used as a safety device to prevent inadvertent ejection on the ground. The valve has two positions: ground safe and flight. In the ground safe position, any gas generated by the inadvertent firing of a ballistic device is vented upstream of the rocket catapult, drogue parachute gun, and 1.4 second-delay initiator. In the flight position, the seat is armed and will eject if one of the ballistic devices is fired.

The escape panels provide paths for crew ejection or emergency ground egress and routes for ground rescue personnel. These panels are located directly above the two ejection seats, each with an inner panel 34 × 48.5 inches (86.4 × 132.2 cm) and an outer panel 37 × 53.8 inches (94 × 136.7 cm) in overall dimensions.

Each seat is equipped with drogue and personal parachutes. The drogue maintains stability during the rapid descent to

15,000 ft (4,500 m) and then during the rapid deceleration below that point so that the personal parachute can be quickly deployed. The drogue is a 78 in. (198 cm) diameter ribbon-type parachute. The personal parachute is 35 ft (10.6 m) in diameter with a 40 in. (101.6 cm) diameter pilot parachute. It is automatically deployed by a "drogue slug", but if that fails it must be manually deployed using the shoulder D-ring. At the beginning of the man/seat separation sequence, the shoulder straps, foot-retraction cables and D-ring cable are cut and the lap belt released.

The personal parachute drogue gun fires 0.2 seconds after the crewman is separated from the seat, and leads to the deployment of the main canopy. A manual D-ring, when pulled, disconnects the lanyard from the extraction gun. Opening of the parachute automatically activates a radio beacon.

The secondary method of operating the escape system begins when a T-handle on the console and both seat T-handles (located under covers on the left hand side of each seat) are pulled.

The manual egress method begins when the scramble handles, located on the right hand side of each seat, are pulled. The crewman is freed from all seat restraints (lap belt, shoulder straps, foot retractor cables), allowing him to scramble out of the Orbiter with or without his parachute and seat kit.

Evacuation on the Pad

Leaving the spacecraft on the pad involves the crew cranking a handle on the Orbiter's side hatch. The actuator handle must first be unlocked and then rotated chockwise by 144 degrees. The latches release their grip and the hatch can be opened.

The circular hatch has a bar to help the crew drop to the ground if the Orbiter should be horizontal. With the landing gear down the upper-most level of the egress hatch is 12.6 ft (3.8 m) from the ground; with the gear up it is 7.5 ft (2.29 m) high.

A second route out is through the left-hand overhead window behind the Commander's seat. The ejection panels carried on the first four test flights can also be removed manually or ground crews can detonate the small separation charges from behind an access door on the leading edge of the right wing.

Thermal aprons would be draped over any areas still too hot for safety and the crew would then leave using a nylon line and a friction device to slow down the descent.

If the Shuttle were still on the pad, the crew would have to get to ground level by sliding in a basket down a cable to a point 1,200 ft (3111 m) away in about 60 seconds (a system used in the days of Apollo). This route is open until two minutes before launch, while the access arm still provides a link to the Fixed Service Structure.

From past simulations it takes the astronauts about two minutes to unstrap themselves, get out through the side hatch, run 25 yards along the gantry swing-arm to where the baskets are berthed, jump in, punch a release handle and begin the ride to the ground.

The men ride the baskets to the landing zone at 55 mph and slide into a retainer net attached between two posts on the ground just in front of an underground bunker. Drag chains attached to the net slow the basket and then bring it to an abrupt halt.

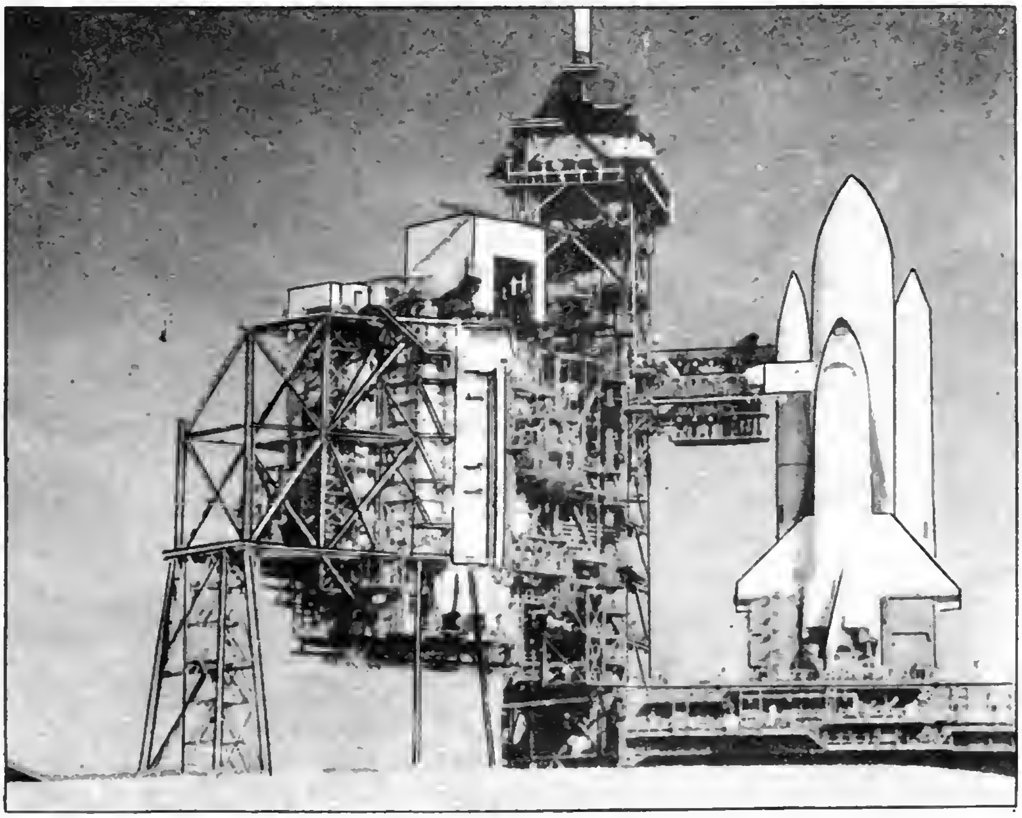
The astronauts then have the choice of seeking refuge in the under-ground bunker or climbing into an M113 armoured personnel carrier and driving to safety.

There are five two-man escape baskets to accommodate the astronauts and the six technicians who remain on the gantry until about one hour before lift off.

The first option, though, is to use the gantry elevator. However, if the conditions were more serious the baskets would be chosen.

Explosives

Columbia contains more than 300 explosive devices. The purpose of the most powerful array is that of destroying the External Tank and the two Solid Rocket Boosters. The charges



On the pad. During the early Shuttle flights astronauts can eject from the Shuttle while still on the pad. They would emerge just above the two dark areas (overhead windows) on the cabin roof. In a lesser emergency they can leave *via* the white room attached to the Orbiter's side and slide down wires in a basket.

NASA

Safety Aboard the Space Shuttle/contd.

Astronaut Young (right) and Crippen test the slide wire escape system before their flight aboard STS-1. Both are wearing Ejection Escape Suits (described in the text).

NASA

would be set off during launch if the Space Shuttle veered off course and threatened population areas.

Ed Simmons, chief pyrotechnic engineer at the Kennedy Space Centre, said that the shaped charges are designed to cut through the External Tank's aluminium liquid oxygen section. Another charge would rip open the liquid hydrogen tank to allow the fuel and oxidizer to mix and explode.

Fire Safety

The Orbiter is equipped with a fixed fire extinguisher system and a set of portable extinguishers.

Three fixed extinguishers are mounted in the mid-deck avionics bay while four (lasting for 10 seconds) can be used anywhere. The fixed units are remotely controlled by switches on the Commander's instrument panel. To suppress a fire behind a display panel, the nozzle of a portable extinguisher is inserted into a "fire hole" on the panel and completely discharged.

At launch, the Air Force provides two recovery helicopters from the time the crew enters the White Room until completion of the launch or the crew leave the pad. If needed, they can transport injured personnel to a designated hospital.

Other Hazards

Recovery of the astronauts once the Orbiter has landed is made more hazardous by the dangers posed by the spacecraft systems. Rescuers are equipped to reach the crew, if necessary, through the double skin of the forward fuselage. The outer structure is a conventional skin and stringer construction covered with thermal tiles, while the inner structure is a welded pressure vessel. Access is easiest through the Orbiter vent doors (typically 0.32 to 1.58 cm in thickness).

Danger areas around the Orbiter at recovery include a 25 ft (7.62 m) exhaust plume directly above the Auxiliary Power Unit exhaust ports, located in front of the tail. There is also a danger area in front of the forward and aft Reaction Control System thruster nozzles and relief valve vent ports. Nitrogen tetroxide and Monomethyl Hydrazine are vented through the relief valves as the temperature rises in the associated tanks unless each system has been made safe by the recovery team.

The Orbiter cannot be approached from the side near the main landing wheels. Tyres/wheels could explode as a result of the extreme heat generated during landing (peak temperatures may not be reached until 30 minutes after touchdown.)

External surfaces could be electrostatically charged, resulting in direct injuries to the recovery team or the ignition of inflammable liquids/gases. Thus, the Orbiter is electrically grounded as soon as possible.

Extreme care has to be taken near the hydrogen vents since escaping gas may be ignited by the high surface temperatures resulting from re-entry.

Acknowledgements

The author wishes to express his appreciation to the Public Relations staff of the Kennedy Space Center and the Johnson Space Center in the preparation of this article. Special thanks to Mr. N. C. Gray, Sub-Systems Manager, Orbiter, Fire, Crash and Rescue, at the Kennedy Space Center.

A BRIEF HISTORY OF THE VOYAGER PROJECT

Part 6

By Dr. J.K. Davies
Continued from the February issue

Previous parts of this series have described the evolution of the Voyager spacecraft and the encounters of Voyagers 1 and 2 with Jupiter. In Part 5, the Voyager 1 encounter with Saturn was described, concluding with the craft returning to inter-planetary cruise mode.

Voyager 2 at Saturn

As 1980 drew to a close, life at the Jet Propulsion Laboratory returned to normal. The teams of visiting scientists returned home to begin the detailed analysis of the volumes of Voyager 1 data returned from Saturn. The excitement of the first flyby was over, the planning for the Voyager 2 encounter was just beginning.

On the basis of Voyager 1's results it was decided to make significant alterations to the plans for Voyager 2's journey through the Saturnian system. Voyager 1 had provided a "broad brush" coverage of the system, while Voyager 2 would be commanded to concentrate on specific targets in an attempt to better understand the discoveries of its twin.

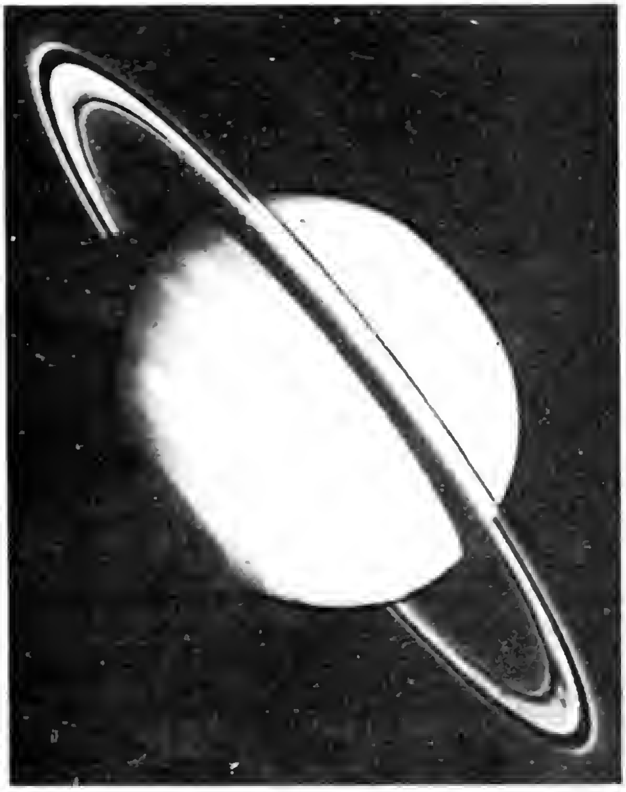
This replanning was made possible by the flexibility designed into the spacecraft nearly a decade before. During the planning stage it was realised that discoveries made by the first spacecraft might require major changes to the encounter operations of the second. An eight month gap between encounters was therefore built into the flight plan. To provide this flexibility and reliability three of Voyager's systems use doubly redundant, reprogrammable digital computers. These are the Command Control Subsystem (CCS), the Articulation and Attitude Control System (AACS) and the Flight Data System (FDS).

The CCS is the brain of the Voyager spacecraft. It can issue commands to the spacecraft subsystems from its memory, decode commands from Earth to update its memory and pass those commands to other subsystems. The AACS controls attitude and points the scan platform on which the science instruments are mounted. The FDS controls the scientific instruments and arranges all of the science and engineering data for transmission to Earth. It also controls the data storage subsystem, an eight track tape recorder capable of storing over 500 megabits of data.

Voyager 2's trajectory past Saturn was determined by the need to keep the spacecraft on course for Uranus (approval of the extension of the mission to Uranus had been received in November) but the complex series of experiments could be changed in line with Voyager's new objectives. These changes were derived by JPL engineers and the mission's principal science investigators. New encounter sequences were then prepared for Voyager's CCS. Before these could be transmitted to the spacecraft they were run through complex computer simulations to ensure maximum scientific return and spacecraft safety. When Voyager 2 reached Saturn the round trip radio time would have increased to nearly 3 hours and if a software problem were to arise useful observing time would be lost while ground control attempted to rectify it.

The main changes to the Voyager 2 science objectives may be summarised as [1]:

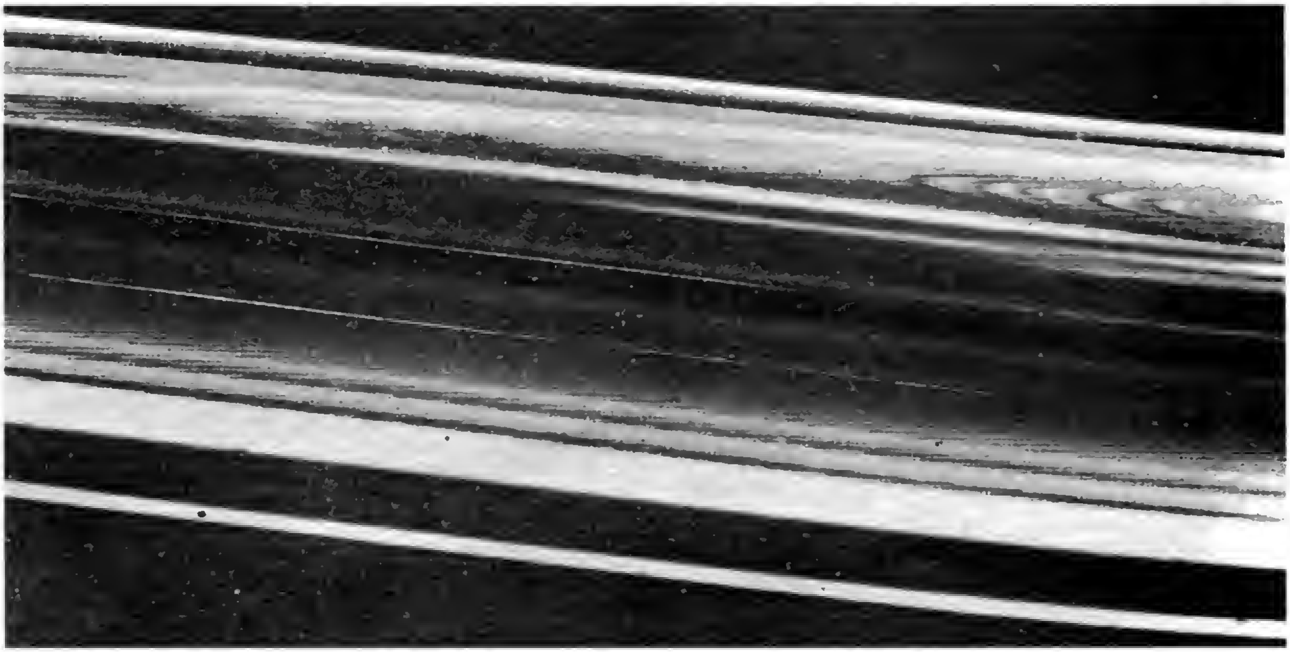
1. Voyager 2 would concentrate on studies of the complex ring system, searching for evidence of small moons which might explain the proliferation of ringlets.
2. Additional studies of the braided F ring would be made including pseudo-stereo imaging and an occultation experiment using the star Beta Tauri.
3. Attempts would be made to view the B ring exactly edge on to determine if the "spokes" observed by Voyager 1 were "levitated" above the ring plane.
4. Special studies of the two eccentric rings observed in the B ring and in Cassini's division.
5. Reduced emphasis of imaging of Titan but a search for aerosols in Titan's atmosphere would be carried out. This had been impossible for Voyager 1 because of a failure in its photopolarimeter.
6. A detailed look at some of the small moons discovered by Voyager 1 and from Earth. Of special interest were the small moons found sharing orbits with the classical satellites, e.g. Dione B and the leading and trailing "Trojan" moonlets of Tethys.
7. A study of electrostatic discharges discovered by Voyager 1. These were found to have a period of 10 hr 10 min, similar to the period of any satellites embedded in the B ring. These discharges may also be related to the B ring spokes.
8. A systematic search on Saturn's unlit side between equatorial and polar latitudes for aurorae.



Saturn as viewed by Voyager 2 on 12 July 1981 from a distance of 42 million km.

NASA

Voyager 2's observations of Saturn's rings would be aided by three factors. Firstly, the spacecraft cameras were more sensitive than those of its predecessor. Secondly, Voyager 2 would pass closer to the rings and, thirdly, the rings would be better illuminated as the Saturnian year continued towards Northern Summer. Additionally, Voyager 2 would be on the illuminated side of the rings at its point of closest approach.



A wide angle view of Saturn's rings just before the craft crossed the ring plane on 26 August 1981. From bottom to top we see: F-ring, A-ring (with the Encke Gap), Cassini Division (narrow dark band), B ring and C-ring. The bright streaks in the B ring are the spokes seen in forward-scattered light.

NASA

Re-encounter with the Jovian Magnetotail

While advanced planning went on for the Saturn encounter, the spacecraft continued to sample the interplanetary medium. In February it made an important discovery [2]. On the 18th Voyager 2 re-encountered Jupiter's magnetotail, some 300 million miles from the giant planet. Dr. F.L. Scarf, principle investigator for the plasma wave instrument, and colleagues Dr. D. Gurnett and Dr. W. Kirth from the University of Iowa, detected noise over a range of frequencies typical of those found at Jupiter in July and August 1979. Consultation with the team monitoring the solar wind plasma streams showed that no solar wind particles were detected at that time, confirming that Voyager 2 was immersed in Jupiter's magnetic tail. Dr. Scarf commented "We are convinced that we were experiencing Jupiter's magnetosphere again". Since the properties of planetary magnetic tails are not well understood this information from Voyager 2 provided interesting new data for theorists. Of interest was the possibility that if the tail stretched all the way to Saturn's orbit then both Voyager 2 and Jupiter's magnetic tail could arrive at Saturn at about the same time. Comparison with Voyager 1 and Pioneer 11 results would provide information on the relative roles of the solar plasma and planetary magnetic fields.

Closing in on Saturn

Although some of the details of the near encounter sequences of Voyager 2 had been changed, and the spacecraft was flying a different trajectory, the general shape of the flyby was the same as for Voyager 1.

Encounter operations began on 5 June 1981 with the observatory phase. Beginning 82 days before encounter and lasting eight weeks, this period of long distance observations allowed a second, short-term, history of the planet to be recorded.

The observatory phase began with a 43-hour session of near continuous photography covering four planet rotations. Throughout the remainder of the observatory phase Saturn was imaged every 72 degrees of its rotation (so five photographs covered a complete rotation). These pictures allowed the assembly of a colour movie showing the approach. The spacecraft's UV spectrometer scanned across the entire Saturn system mapping the intensity of the emissions from Titan's orbit. As with Voyager 1, radio emissions were sampled daily with the planetary radio astronomy experiment and frequent scans were made by the plasma wave instruments. Also during this phase numerous calibrations of the scientific instruments were made to ensure the best possible scientific data during the near encounter.

During the latter half of June, Voyager control reported the failure of an electronic chip within the Flight Data Subsystem. The event was not regarded as significant since it represented only a very small fraction of the spacecraft's memory capability.

On 31 July, 26 days before closest approach, the narrow angle camera could no longer capture the entire planet in a single frame. The imaging was switched to two-by-two mosaics, using four frames to build up each complete picture. At this point Voyager 2 was a little less than 25 million kilometres from Saturn and had entered the 12-day Far Encounter 1 phase. During this phase, the observations were continued as the detail visible on the planet increased day by day.

By 11 August the range to Saturn had reduced such that two by two mosaics no longer provided full coverage of the planet. The Far Encounter 2 phase had begun. At this time Voyager 2 was 14.5 million km from closest approach and all of its instruments were gathering data on the planet, satellites and radiation environment. During this period, a series of photographs of the B ring were taken by the narrow angle camera as more details of the elusive spokes were sought. Spoke imaging took place over a period of about 30 hours with the Voyager camera panning left to right to take the four images necessary to ensure complete coverage of the ring system. Each four image sequence lasted about 16 minutes.

On 18 August a final trajectory correction manoeuvre was made to refine Voyager 2's aim point. This was necessary because it had been estimated that an error of a mere 20 seconds at encounter could compromise some of the scientific results. In the end Voyager 2 arrived only 66 km off its aim point and 3.1 seconds ahead of schedule.

Late in the Far Encounter Phase Voyager 2 made its closest approach to Iapetus, Hyperion and Titan. Just 18 hours before closest approach the spacecraft began its near encounter oper-

ations. A second intensive survey of Saturn was about to commence.

Close Encounter

The near encounter with Saturn will be described here briefly, but additional details may be found in References 3-7. The close encounter operations were more complex than those of Voyager 1 because it had been instructed to study specific targets, requiring extensive use of the movable scan platform carrying the scientific instruments. On the last day of the Far Encounter 2 phase there had been 33 different observations and the near encounter would involve rapid switching between a number of targets.

On 22 August, while still 3½ days from Saturn, Voyager 2 passed the mysterious, low density moon Iapetus. Iapetus has long been known to have hemispheres of widely differing reflectivity (or albedo). The closest distance was a little over 900,000 km but even this was 1.5 million km nearer than Voyager 1. By monitoring the effect of Iapetus' weak gravitational field on the trajectory of Voyager 2 the satellite's mass, and hence its density, could be determined. This showed Iapetus to have a density of only 1.1 gm/cc. This very low figure suggests a composition of 35 per cent rock, 55 per cent water ice and about 10 per cent methane ice. If this is true Iapetus contains over 10^9 tonnes of organic material.

This is a very interesting result since Voyager 2's photographs showed that the leading, dark hemisphere of Iapetus appears to be covered by a gigantic brown stain. This stain is typical of the "organic gunge" or "intractable polymer" formed in pre-biotic chemistry experiments and which Carl Sagan has described as "tholins". It may be significant that this material is concentrated on the leading edge of the satellite, for here it may receive a significant amount of ionising radiation as Iapetus ploughs around in its orbit through the complex particle and radiation environment of Saturn. It is far too early to regard these conclusions as certain but there is a distinct possibility that Iapetus is indeed covered by organic material. If this is true then study of the chemistry of Iapetus and Titan could be most rewarding in the search for the origins of life.

A mosaic of Enceladus from images taken through the clear, violet and green filters on 25 August at a distance of 119,000 km. The surface grooves probably result from deformation of the crust and the smooth areas show that the moon has recently experienced a period of internal melting.

NASA

The next moon to come under intensive scrutiny was Hyperion, a small body which Voyager 1 had hardly glimpsed. As Voyager 2 imaged Hyperion the changing orientation of the satellite caused it to appear in a variety of forms. Before its true shape could be determined the satellite was described as shaped like a peanut, a tuna-fish can and a hockey puck. Eventually the semi-official description of hamburger-shaped evolved with dimensions of about 210 by 360 km. Of great interest was the discovery that the long axis of Hyperion points out of the plane of its orbit - it had been expected that the moon would be gravity gradient stabilised to point directly towards Saturn. To have taken up this peculiar attitude Hyperion must have been struck by another body, probably within the last 100 million years.

As Voyager 2 sped towards Saturn it took a look at Titan, although the range was over 600,000 km, a hundred times further than its predecessors flypast. Even at this range the cameras showed that the polar hood observed by Voyager 1 had changed. It was no longer a hood, but more of a collar surrounding the pole. Voyager passed by Titan about 18 hours before closest approach to Saturn and shortly after it formally entered its near encounter phase.

As the spacecraft closed in on the planet it continued to photograph the rings and details on the planet itself. The search for moonlets embedded in the rings continued in vain. Four hours and 20 minutes from closest approach the newly discovered moon 1980S26, known as Dione B, was glimpsed at a range of 318,000 km. Shortly afterwards the first of two planned occultation experiments began. The structure of Saturn's rings was to be investigated with unprecedented accuracy.

Probing the Rings

The occultation of the star Delta Scorpii was one of Voyager 2's most important ring observations. For 2 hours and 20 minutes the spacecraft's photopolarimeter was aimed so that the star was viewed through the ring system. As the star blinked on and off Voyager was able to count the number of ringlets and measure the size of particles down to about 500 m in size. The star, magnitude 2.34, was chosen because of its brightness and because its occultation by the rings took place in Saturn's shadow, minimising the interference from scattered sunlight. By ingenious computer processing the results from this experiment were reconstructed in the form of "photographs" showing the fine structure within the 70 km-wide F ring strand. Resolution was at least 10 times higher than with the best optical images.

During the occultation experiment over 700,000 data points were recorded at a rate of about 100 per second. Initial analysis suggested that resolution could be as high as 100 m in places, and that the thickness of the outer edge of the A ring was less than 200 m.

A search was made for fluctuations in ring particle density since spiral density waves within the rings had been proposed to account for the complex structure. Wave features were found with peak to peak distances ranging from 100 km to the 100 m resolution limit.

The Inner Moons

During the occultation experiment Voyager 2 had passed Dione with a maximum possible resolution of 12 km, some four times lower than Voyager 1 because of the increased distance. Soon after, Mimas was passed at a distance of about 310,000 km and Saturn closest approach was less than an hour away.

During this hour Voyager made its closest approach to three of the newly discovered small Saturnian moons 1980S25 (trailing Tethys), 1980S28 (orbiting outside the A ring) and 1980S26

(orbiting outside the F ring). Both 1980S25 and 1980S28 were imaged at resolutions of about 5 to 10 km before Voyager 2 skimmed 100,000 km above the cloud tops of Saturn.

Closest approach occurred at 8.21 JPL local time, as Voyager 2 swept down on the rings from above their illuminated side. As seen from Earth Voyager 2 proceeded around the right hand side of the planet, the gravitational attraction of Saturn turning the trajectory through almost 90 degrees and swinging the craft onto its course for distant Uranus.

Nine minutes after closest approach Voyager passed 1980S27, another small moonlet, before its rendezvous with Enceladus. Voyager 1 had passed 200,000 km from Enceladus and had shown that at a resolution of 12 km it was unusually smooth. As Voyager 2 closed in, on Enceladus it was revealed as an exciting new world. In general terms, it resembled Ganymede, although with a diameter of about 500 km it was only a tenth of size of the Jovian satellite.

Some regions of Enceladus showed impact craters up to 35 km in diameter while other areas, those imaged by Voyager 1, are smooth and uncratered. Like Ganymede and Europa, Enceladus is also criss-crossed by linear grooves several hundred kilometers long. These probably represent faults resulting from crustal deformations. The large uncratered areas on Enceladus must be young, probably less than 100 million years old, suggesting recent geological activity.

Voyager 2 was still working well 15 minutes after Enceladus closest approach as it disappeared behind Saturn to begin the 90 minute Earth occultation phase (Sun occultation occurred 6 minutes later). While out of sight from Earth the spacecraft crossed the ring plane about 745 km outside the C ring. Once out of contact with Earth, Voyager's scientific observations were the responsibility of the spacecraft's CCU which would use commands stored in its memory to control the complex array of instruments. Mission controllers waited expectantly for the spacecraft to reappear.

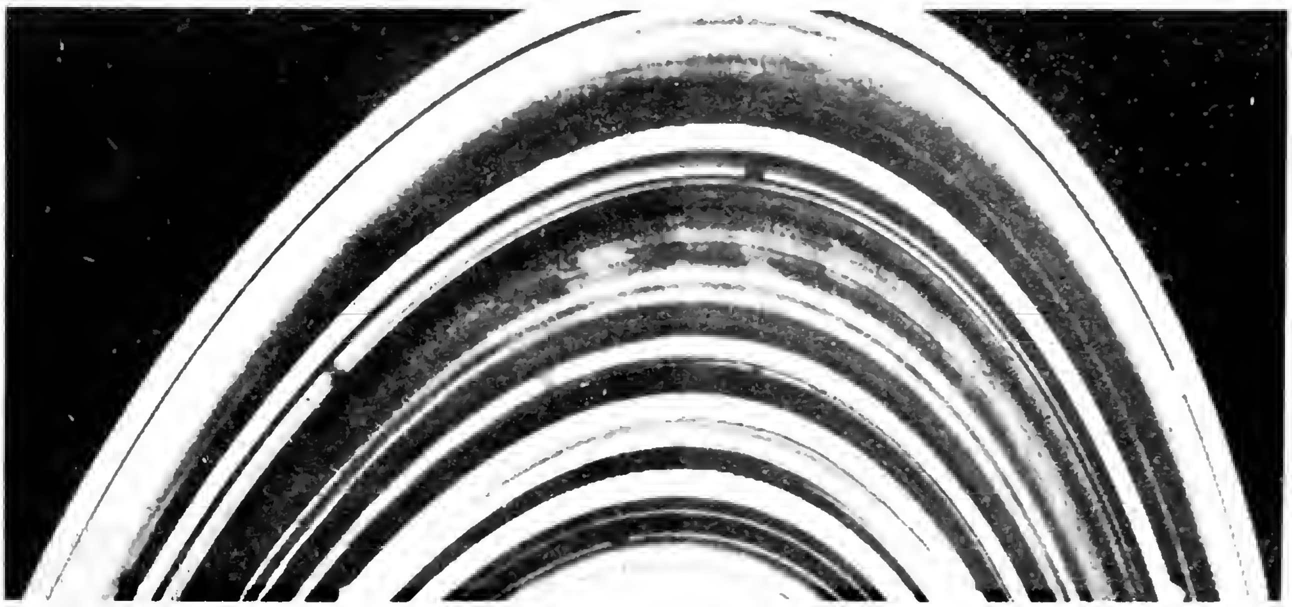
The night side of Titan on 25 August seen through green and violet filters. The original shows orange inner and blue outer rings, caused by sunlight scattering through Titan's extensive atmosphere.

NASA

In Trouble

When contact was re-established it was obvious that all was not well with Voyager 2. Instead of Saturn, photographs showed only empty space. The 220 lb scan platform carrying Voyager's cameras, spectrometers and photopolarimeter had stuck and was pointing uselessly into space. The platform was jammed at 260 degrees in azimuth and 20 degree elevation and would not respond to commands to slew in azimuth. Immediately ground controllers commanded a slew in platform elevation to keep the sensitive instruments pointing away from the Sun. This was followed by an instruction to the scan platform not to respond to azimuth commands from the spacecraft. Several azimuth scans had already been sent by the CCU to the platform but the platform had failed to respond.

Voyager 1 had suffered a similar failure early on in its mission, diagnosed as a piece of teflon jammed in a gear wheel. This was considered to be a possible cause of the new problem. However, the fact that the failure had occurred shortly after



Spokes are visible in the B-ring in this picture taken on 28 August from the unlit side of the rings.

NASA

Voyager 2 is now en route for an encounter with Uranus in January 1986 and, if all goes well, with Neptune in August 1989. Even if it fails, it will have accomplished its original mission.

NASA

Voyager crossed the ring plane strongly suggested that the spacecraft had been struck by a ring particle. Measurements by the plasma wave instrument suggested that the spacecraft had been bombarded by dust particles at this stage. However, later analysis showed that the platform failure had occurred 45 minutes after the crossing, increasing suspicion that the fault lay within the platform itself. Later in the day ground controllers were able to move the platform about 10 degrees in azimuth but further attempts to free it were delayed to allow time for a full evaluation.

Although the loss of data from the scan platform instruments was unfortunate, NASA project officials were able to announce that nearly all of the mission objectives had been achieved before the failure. Lost observations included two thirds of the planned coverage of Enceladus, close photography of Tethys, and imaging of the dark side of the rings. Non-imaging data lost included a further occultation experiment using the star Beta Tauri, infra-red measurements of the ring material as it entered the planet's shadow, and ultra-violet spectroscopy of ring material by observations of the Sun through the rings. One fields and particle manoeuvre was also lost. Dr. Ed Stone spoke for everyone when he said "We were fortunate that the platform didn't stop a few hours earlier".

As Voyager began to leave Saturn ground controllers strove to bring the scan platform back into action. Photographs were obtainable but only at a cost - slewing the spacecraft was using precious attitude control gas needed for the journey to Uranus. On 28 August, three days after closest approach, the platform was successfully moved by ground command to point the instruments at Saturn once more. Early tests showed that the platform could be moved, although response was sometimes hesitant and slow. Response improved steadily over the next few days and the platform was returned to the onboard computer-sequences for the imaging of Phoebe, on 4 September.

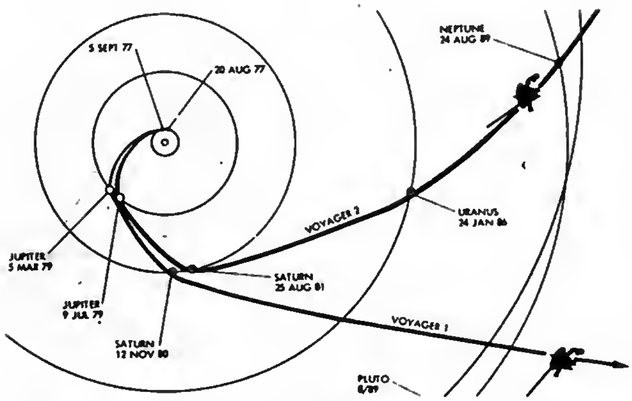
Voyager 2 flew no closer to Phoebe than 2 million kilometres but even at that range was able to return useful results. Phoebe was shown to be about 200 km in diameter and very dark. Earth-based measurements had assumed a more reflective surface and deduced a diameter half that measured by Voyager. The rotation period was determined as about 9 to 10 hours, the only one of Saturn's moons which does not always show the same face to the planet. Phoebe orbits Saturn in a retrograde direction, and in the ecliptic plane rather than the plane of the equator. All these observations indicate that Phoebe is a captured asteroid and did not form in Saturn's original nebula.

As operations to repair the scan platform continued more trouble struck. On 8 September diagnostic and requalification tests were being carried out when the motion became erratic. The platform was being moved from side to side in a series of exercises at different elevations and rates to evaluate its performance. The problem is now believed to be related to wear with the gear mechanisms and lubrication problems. Platform operation in elevation is unaffected but movements in azimuth are restricted in speed and range. Although Voyager's capability will be limited, operation at Uranus should still be possible.

The Uranus Option

Voyager 2 is now in interplanetary cruise mode and beginning its five year coast to Uranus, where it will arrive in January 1986. As it continues to recede from the Sun it will, like the two deep space Pioneers and Voyager 1, continue to sample the interplanetary medium with its fields and particles experiments. Uranus is a long way in the future but Voyager 2 has already covered half the distance from Earth to the planet since its launch in 1977. What then is the likelihood that the spacecraft will still be operational when it arrives at Uranus four years hence?

Two factors are critical for the continuation of the mission: the health of the spacecraft and the political will to continue



The paths of the two Voyagers compared.

to fund ground support operations. Each contains several imponderables.

Voyager 2 is in its fourth year of operation and has two major equipment problems: the failing scan platform and the radio receiver problems described in Part 2 (*Spaceflight*, March 1981). It is now considered unlikely that the platform problem is temporary and therefore its operation throughout the remainder of the mission will be subject to certain limitations. How serious these will be remains to be seen and encounter operations at Uranus will be planned around a minimum use of the high speed drive. If necessary it should be possible to park the camera and aim the whole spacecraft at specific targets, but this option would consume considerable amounts of propellant and would probably prevent the continuation to Neptune. If a means of working around the problem can be found significant results could still be returned from Uranus even if the full range of activities was not possible.

The problem concerning the radio receiver may be more critical. Voyager 2 is operating on its back-up receiver after a still unknown problem disabled the prime unit early in the mission. The back-up radio also has a failed tracking loop capacitor. This unit would normally allow the spacecraft's receiver to constantly retune to the correct frequency as the

Uranus as seen through the 82 inch McDonald telescope on 15 February 1948. The moons Oberon, Ariel, Miranda, Umbriel and Titania, are visible. Voyager may increase our knowledge of this system enormously.

Earth's rotation or the acceleration of the spacecraft caused the radio signal to be Doppler shifted. This particular problem is not too serious since NASA engineers have developed routines to transmit on a constantly changing frequency so that the frequency received at the spacecraft is constant. However, should the remaining receiver fail completely then communication with the spacecraft will no longer be possible and Voyager 2 will revert to its back-up mission load stored in the CCS. The mission will then continue with a simplified procedure of experiments controlled entirely by the CCS. No updating or commanding from Earth will be possible and this, coupled with possible platform snags, could seriously degrade the data returned. The possibility that the spacecraft could cruise past Uranus with the scan platform misaligned and transmitting pictures of deep space, while controllers look on helplessly, does not bear thinking about.

There is a certain irony in all these problems since, as explained in Part 1 (*Spaceflight*, February 1981) the two spacecraft were switched over just prior to launch and the spacecraft originally designated for Voyager 2 is now heading out the ecliptic with two radio receivers operational and a good scan platform!

However, mission controllers are optimistic that the hardware will remain operational for the extension to Uranus and Neptune.

The second major unknown at present is whether funds will be available to support the mission for the additional five years or more.

Voyager 2 will flypast Uranus whatever happens. It would be a tragedy if the spacecraft was silent, cut off by an administration that was already forgotten.

It would not be appropriate to end this account of the Voyager mission on such a gloomy note. The two spacecraft have already completed their missions successfully, any new information is a bonus. The two spacecraft, larger and more complex than previous deep space probes have done almost everything asked of them. They have traversed the asteroid belt, the radiation belts of Jupiter and the rings of Saturn with hardly a hitch. Awards for achievement have been heaped upon the Voyager Project teams and the scientific data returned will keep planetary scientists busy for decades. Already our appreciation of the giant planets has increased considerably and the complexity and variety of their satellites and rings has taken the scientific community by storm.

How will Voyager be remembered? It is difficult to identify a single image, or a single discovery. The active volcanoes on Io, cratered Callisto, Jupiter's ring and giant weather systems, Saturn seen clearly at last or its multi-ringlet system and fractured icy moons; everyone will have their own preference. Perhaps the most significant recollection will be one of a tremendous success for everyone who looks outward to the planets.

Acknowledgements

It is a pleasure to acknowledge the help of a number of people in the preparation of this series, particularly the staff of the public affairs office at NASA JPL, and R.L. Heacock, A. Danni and R.P. Laeser of the Voyager Project Office. Special thanks also to Ann, Diane, May and Marilyn for typing the manuscript and to Maggie for helping with the proof reading.

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SPACE REPORT

ARIANE DECLARED OPERATIONAL

On 25 January representatives of the states participating in ESA's Ariane programme unanimously declared the launcher to be qualified and fully operational. On this occasion, the Member State representatives warmly congratulated all those in the Agency, the Centre National d'Etudes Spatiales (CNES) and European industry who had contributed to this impressive achievement.

The initial analysis of the fourth and final Ariane test flight last December confirmed that the launcher performed as expected. Ariane L04 injected the European Maritime Communications Satellite (MARECS 1) into a transfer orbit whose apogee of 36,051 km was only 5 km off its planned value. The Viking engines on the first and second stages performed as planned, thus confirming that the vibration problem encountered on the second test flight had been eliminated successfully.

L04 was the first launch with representative operational constraints. In order to ensure injection of the spacecraft into an optimal orbit, the launch window was limited to only 45 minutes per day. After a 24-hour postponement (due to a mechanical problem with the liquid oxygen feed valve plates on the third stage), the 29 hr 20 min countdown ticked away without a single interruption, leading to a launch at the first second of the 45 minute window.

As on the third test flight, a series of manoeuvres of the third stage, reproducing the injection into orbit of two different satellites on a single launch, was successfully carried out.

The first series of seven operational launches, known as the promotion series, will now be carried out under ESA auspices. Subsequently, responsibility for the marketing, manufacture and launching of Ariane will be handed over to Arianespace, a private company set up for this purpose. The promotion series includes four launches in 1982, with three in 1983.

EUROPEAN PAYLOAD SPECIALISTS

European Space Agency Spacelab payload specialists Dr. Wubbo Ockels of the Netherlands and Dr. Ulf Merbold of West Germany arrived at the Marshall Space Flight Center, Huntsville in January to complete their training for the first Spacelab mission, presently scheduled for September 1983.

Ockels, Merbold and two other payload specialists, Dr. Michael Lampton and Dr. Byron Lichtenberg of the United States, have been in training for the mission since August 1978. The two Europeans moved to the United States because training for the flight has intensified.

Of the four payload specialists training for the first mission, one American and one European will actually go into space. The other two will operate groundbased support equipment and support the pair in orbit.

Spacelab 1 is to be a seven-day, joint NASA/ESA mission during which some 70 investigations in five different disciplines will be conducted.

VENUS CONFERENCE

Dramatic new findings about Venus were reported at the NASA-University of Arizona-sponsored first International Conference of the Venus Environment, held in Palo Alto, California on 2-6 November, 1981.

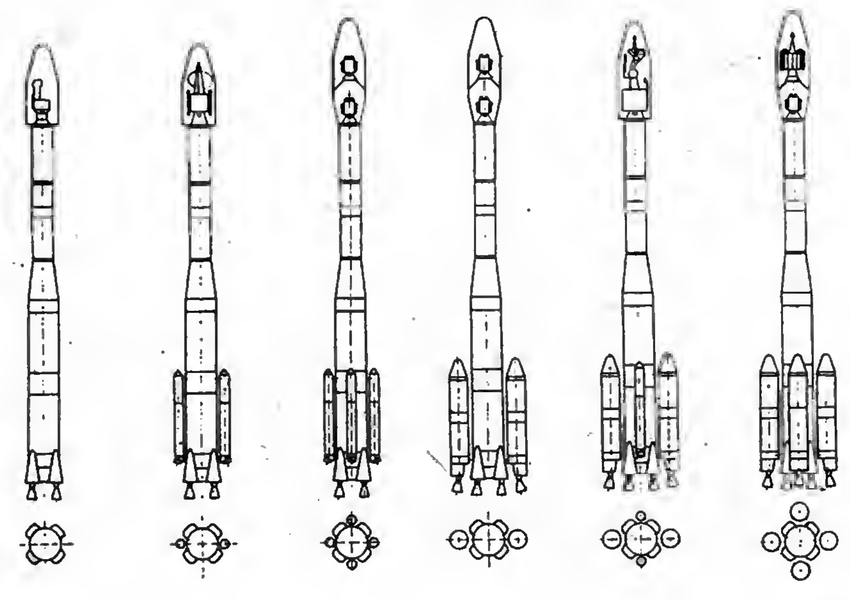
These findings include: evidence for two major, currently active volcanic areas on the planet; the probability that these areas are the principal vents for the planet's internal heat; quantified findings that Venus has a thicker crust than Earth and is a "one plate" planet with little plate tectonics; and complete, self-consistent models of Venus' cloud system and greenhouse effect. Considerable progress has also been made in understanding overall atmosphere circulation (with implications for Earth); and there is strong new evidence for former Venusian oceans on the scale of the Earth's oceans.

Several hundred scientists attended the recent Venus conference. Much of the new information comes from data returned by the Pioneer-Venus spacecraft of 1978 and their 30 experiments.

Much of the significance of the Venus findings lies in the fact that the Earth and Venus appear to be almost copies of each other. Scientists believe the Earth would become a virtual Venus if we could stop its rotation, remove the Moon, and move it slightly closer to the Sun. Therefore, studies of Venus provide a variety of insights into Earth mechanisms.

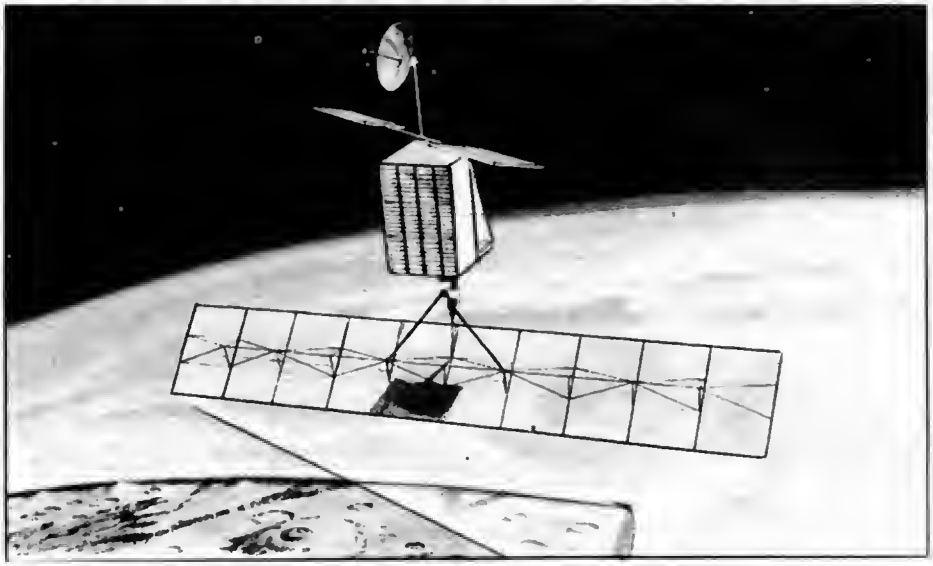
New Venus discoveries included:

1. Apparently there are two major volcanic regions, Beta Regio and the Scorpion Tail of Aphrodite Terra, the largest continent-like upland region on the planet. There



The Ariane 4 launcher, approved by ESA's Ariane Launcher Programme Board on 25/26 January, will be able to take 4,300 kg into transfer orbit on the most powerful of its six versions. By contrast, Ariane 3 will be able to handle 2,400 kg. Other features include: increasing first stage propellant from 140 to 220 t by stretching the tanks, adding combinations of liquid and/or solid propellant boosters (see diagram), increasing the payload fairing to 4 m in diameter. First launch is expected in 1985, with operational status being reached in 1986.

The six versions, shown here, are the 40, 42p, 44p, 42L, 44Lp and 44L. The second digit indicates the number of boosters carried, while the letters show their propellant type (L: liquid, p: solid).



The Venus Orbiting Imaging Radar spacecraft, designed to map the planet's surface at high resolution using radar techniques, has been cancelled. It was to have been launched in about 1988. The mission (a further picture can be found on the cover of last month's *Spaceflight*) may be considered important enough for engineers to come up with a simpler, cheaper craft. Ball Aerospace, builders of the Earth-orbiting Solar Mesosphere Explorer, have suggested that low-cost Venus and Mars probes could be based on SME.

is evidence for continuous and current volcanic activity at both places.

2. Detailed analysis of Venus' global topography and detailed comparisons with global crustal density (derived from gravity data), show that Venus apparently has a thicker crust than Earth and is a "one plate" planet. Substantial evidence indicates that its crust is not broken into many continent-bearing plates, floating on the liquid interior, as is the case with Earth.
3. Because of its thick, planet-wrapping crust, most of Venus' interior heat appears to come out in its two volcanic regions, unlike Earth. Earth vents its heat at many points, especially at the constantly-expanding mid-ocean ridges. Concentration of Venus' lightning over just two volcanic regions suggests fairly frequent current volcanic activity in both places.
4. Though Venus' continents appear not to drift around on crustal plates as Earth's do, crustal density measurements suggest local uplifting of large regions. This is probably due to up-flowing convective plumes, resulting from circulation of interior magma. The most prominent of these are Aphrodite Terra and Ishtar Terra. Vertical motion of the crust is also suggested by the several deep rift valleys; one, the lowest point on the planet, at the Scorpion Tail of Aphrodite.
5. Beta Regio, a region larger than the Hawaii-Midway chain, appears to be a huge double-shield volcanic region and is apparently the most active region on the planet. This is shown by variations in crustal density, apparent old lava flows and the region's 6,100 m (20,000 ft) height and huge size. Beta is believed to sit over a powerful, upflowing convective plume, deep in Venus' interior magma.
6. The new topography data show other smaller volcanoes and one crustal rift 1,500 km (810 mi) long.
7. Venus' clouds are "upside down." There is a smog layer on top 15 km (8 mi) deep, and Earth-like condensation clouds (made of sulphuric acid droplets) below 57 km (31 mi) extending down to 48 km (26 mi). These condensation clouds are patchy and vary in density. They produce drizzle but seldom hard rain, and in general are only 10 percent as thick as comparable Earth clouds. Scientists have also now chartered and quantified the basic cycle of chemical reactions in the clouds.
8. Unlike Earth, which absorbs most solar heat on its surface, Venus absorbs most solar heat in its clouds. In the cloud layer is a single convective circulation cell which carries heat from equator to pole. Earth has three linked major circulation cells,
9. Venus' cloud region is also a shell of high-speed winds which encircles the planet. Above this wind layer, the atmosphere is almost dead calm. There are two explanations for these high-speed winds on a planet with no rotation. Both propose wave (eddy)-pumping of the enormous momentum of the planet's dense lower atmosphere to higher altitudes where the momentum remains. One of these proposed mechanisms involves large horizontal eddies; the other, tidal effects as the lighted hemisphere moves slowly around the planet. Weather theoreticians agree that: wave pumping mechanisms are critical to understanding Earth' weather; are not well understood on any planet; and have been brought into prominence by recent Venus work.
10. Venus appears to have had an ocean and lost it to space. During the Solar System's early history (when scientists believe the Sun was 30 percent cooler) Venus' atmosphere and environment could have been Earth-like. Strong evidence for this lost water remains today in the definitive measurement of the ratio of deuterium to hydrogen. (There is 100 times as much deuterium relative to hydrogen on Venus as on Earth. This measurement was found for the first time in the Pioneer data during the recent Venus conference.) With water abundant, the planet may perhaps have sustained life during the early years of the Solar System's history. When the runaway greenhouse effect began, it wiped out most existing phenomena on the planet and replaced them with today's furnace-like environment.

SHUTTLE MATERIALS PROCESSING

NASA's Office of Space Science and Applications and the CTI Corporation of California, have signed a Joint Endeavor Agreement on 20 January which is expected to lead to the flight of a CTI-developed materials processing device on four future Shuttle flights.

The agreement is part of a new NASA approach to government-industry partnerships which could develop future

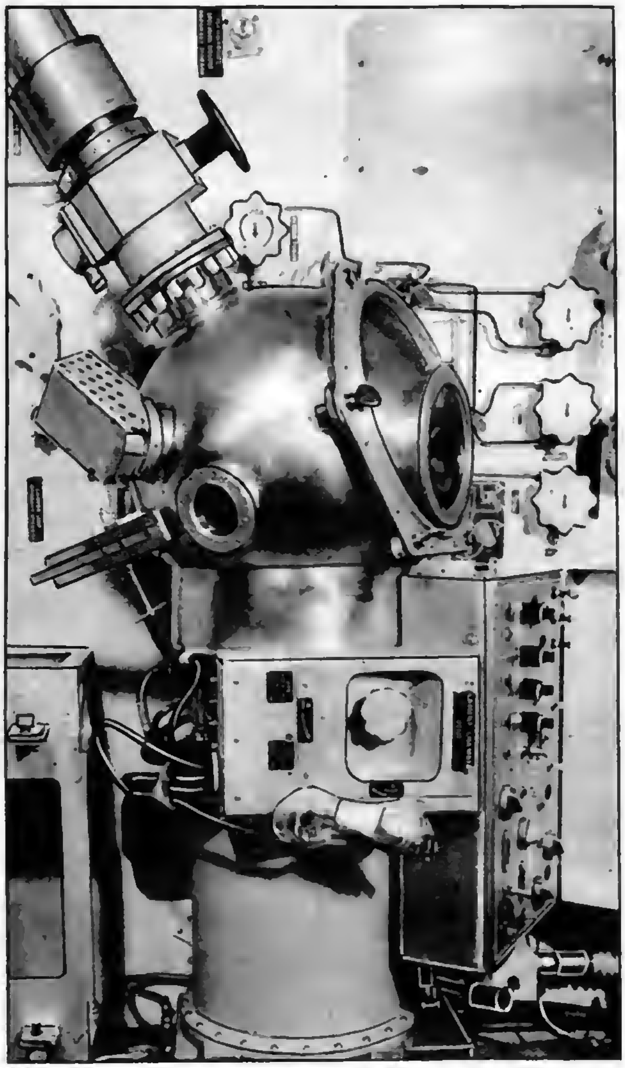
applications or technologies for space-flown devices. It will be managed by the Materials Processing in Space project office at NASA's Marshall Space Flight Center.

During the first phase of the agreement CTI will design a low-cost, multichamber, alloy solidification furnace system to be operated in the micro-gravity environment provided by the Shuttle. The second phase will consist of the development, testing and integration of the CTI furnace into the Shuttle.

The final phase will consist of the Shuttle flight of the furnace and further efforts by CTI to assess the flight system and the commercial feasibility of the products it manufactures.

A principal interest is investigating the manufacture of immiscible alloys in the micro-gravity environment of space. Alloys are blends of metallic and, often, non-metallic elements which create a new material with the combined properties of the constituents. On Earth, many theoretical alloys cannot be produced due to the settling of one or more of the elements in the mixing stage. This is often due to the density variations of the elements themselves and the effect of gravity on the heavier elements.

These troublesome effects have been found to be reduced substantially or completely in the micro-gravity conditions of Earth-orbiting spacecraft. CTI is interested in pursuing the commercial application of some of these specialty alloys.



A furnace was carried in the Skylab space station for micro-gravity experiments during 1973/74. NASA

ORBITING TELESCOPE STUDIES

The Perkin-Elmer Corporation has been selected by NASA's Ames Research Center in California to conduct an in-depth study of segmented mirror technology. The study is the first step in the development of giant mirror systems, 50 to 100 ft in diameter, which will be deployed by the Space Shuttle in orbit hundreds of miles above the Earth. These large mirrors will be formed by the assembly of many smaller mirrors (segments).

To prepare for the astronomical space projects envisaged for the 1990's, objective mirrors such as the Large Deployable Reflector, which will operate over the wavelength range from 2 to 1000μm, will be required. NASA is currently investigating the optimum mirror segment material and state-of-the-art fabrication techniques suitable for these assemblies. Perkin-Elmer will devise and evaluate various technical approaches for large precision mirrors that will be dramatically lighter and more easily fabricated than today's most advanced concepts.

"Segmented mirrors will eliminate the necessity of grinding large heavy mirrors in one piece and will permit us to design deployable mirrors that will fit into the present Space Shuttle cargo bay," said John Russo, Manager of the Science and Applications Department at Perkin-Elmer.

One critical issue being addressed is how large and/or flexible a mirror segment can be and remain sufficiently stable so that active figure (shape) sensing and control is not required to compensate for thermal and gravitational distortions. How to economically produce a large number of matching off-axis parabolas is another aspect that will receive considerable attention.

Space astronomy optical systems of larger size and extended capabilities will become possible when the goals of the Segmented Mirror Technology Study are achieved. NASA's present plans combine the infrared and submillimeter radio astronomy disciplines in a design for a collector system comprising a primary mirror ranging from approximately 15 m (50 ft) in diameter to a larger 30 m mirror. The 15 m telescope will be deployable in space as a detached, free-flying payload. The larger 30 m concept will require the telescope system to be assembled in space because its projected size precludes automatic deployment.

KILLER OF THE DINOSAURS?

For perhaps two months, millions of years ago, the Earth was wrapped in a cloud of dust so thick that the Sun was obscured and temperatures fell below freezing, writes Gerald L. Borrowman.

Within six months, according to a new version of a 2-year-old theory, the landscape was littered with carcasses. Whole species became extinct after plants stopped growing.

An asteroid or comet, crashing on Earth and kicking up huge clouds of dust 65 million years ago, ended the 140-million-year reign of the dinosaurs according to atmospheric scientist Owen Toon of NASA's Ames Research Center.

"It's one of the longest-standing mysteries in science," he said. "If it could happen to them, it could happen to us."

The extinction of the giant reptiles launched the age of mammals, which survived, Toon theorizes, because they were small enough to burrow underground for warmth "and could probably stumble across enough food," including dead dinosaurs.

He said cold and the inability to find food, probably killed off any creature that weighed more than 75 lb.

The idea of a dust-producing collision was proposed in 1980 by a team of scientists led by Walter Alvarez of the University of California's Lawrence Berkeley Laboratory. They based the theory on geologic evidence that, about 65 million years ago, a thin layer of debris was deposited around the Earth. The

MORE MOONS OF SATURN

Four, and possibly as many as six, new satellites of Saturn have been found, using data from the Voyager 2 encounter with the planet in August last year.

The discoveries bring the number of known Saturnian satellites to between 21 and 23. The two "possible" satellites were seen in only one observation each, so their orbits are not yet confirmed.

The innermost satellite found by Dr. Stephen P. Synnott of the Jet Propulsion Laboratory in California moves at about the same orbital distance from Saturn as the satellite Mimas. The object's existence was originally suspected from data supplied by charged-particle instruments aboard Voyager 2.

A third (and possibly fourth) companion of the satellite Tethys appears to move in what Synnott calls a "horseshoe" orbit. Synnott is sure an object is there, but he is not certain yet, because of resolution limits in the photographs, whether it is one or two objects. Satellites in horseshoe orbits swap over orbits as they approach each other.

Another satellite was found by Synnott at a point about 60 degrees ahead of the satellite Dione, the second found in that region. The first was discovered in Earth-based observations in 1980. Another satellite was found about 350,000 km (217,000 mi) from Saturn, between the orbits of Tethys and Dione. It circles Saturn every 2.44 days.

Synnott's final observation, a faint streak in a Voyager 2 image, indicates that a satellite (the "possible sixth") may exist about 470,000 km (292,000 mi) from Saturn, between the orbits of Dione and Rhea. Its period would be, Synnott calculates, 3.8 days. The object that shares the orbit of Mimas is about 10 km (6 mi) in diameter. All of the others are about 15 to 20 km (9 to 12 mi) in diameter.

Synnott, a member of the Voyager navigation team, also found two new satellites orbiting Jupiter in images he studied after the Voyager encounters in 1979. Before Voyager, Saturn was known to have at least 10 sizeable moons.

concentration of certain metals in this layer is much different than that found in the Earth's crust, but about right for an asteroid.

The group concluded that a meteorite, perhaps 8 miles across, caused a dust cloud that darkened the Earth for several years.

ARIEL 6 SWITCHED OFF

Ariel 6, the last of the "UK/Ariel" scientific satellites, was switched off on 25 February and the control centre and ground station at the Rutherford Appleton Laboratory was shut down at the same time. The final series of scientific observations from the satellite were undertaken on 8-19 February. The spin rate of the satellite has, after two successful spin-up manoeuvres, now reduced due to aerodynamic drag to a level where stable observations with the experiments are no longer possible.

The satellite was launched by a NASA Scout from Wallops Island in Virginia on 2 June 1979. It carried a cosmic ray detector, two X-ray astronomy experiments, and two technology experiments from the Royal Aircraft Establishment Farnborough.

Many substantial scientific results have emerged. The Bristol University cosmic ray experiment has provided, for the first time in a single exposure, observations of ultra-heavy cosmic ray particles throughout the entire range of elements from iron to uranium. The results obtained show a number of surprising features. To highlight just one, there is a striking overabundance of elements with charges between 58 and 72. This implies a corresponding overabundance of such elements in the cosmic ray source regions, and, when taken together with the abundances over the whole of the remaining charge range, will enable better understanding of the mechanisms of cosmic ray production and acceleration to be obtained.

The X-ray experiments have also had a number of outstanding scientific successes. The Leicester University instrument, primarily designed to undertake follow-up observations of sources discovered with the Ariel 5 satellite, has studied about 30 X-ray objects in detail. Highlights include excellent spectral and variability data from several black hole candidates, and the determination of precise rotation periods for a number of accreting neutron stars. Examination of the spectra of several active galaxies (e.g. quasars and seyferts) has revealed the presence of strong iron line emission. This indicates a substantial presence of heavy elements in the gas surrounding the active nucleus. In addition, emission spectra of the nuclear regions indicate the existence of very high temperatures. Simultaneous optical and X-ray observations have also been carried out.

The low energy X-ray telescopes provided by Birmingham University and University College London were designed to explore a relatively new region of the spectrum. Results include the detailed study of 20 sources. One of these (Cygnus X2) has been shown to contain a white dwarf, an unexpected result

The Ariel 6 satellite being prepared for launch.

Space Report/contd.

since neutron stars are usually involved in the production of X-rays in binary systems or star pairs. Line emission has been detected during a flare from a star in Ursa Majoris which will permit a detailed examination of the gas heating process. In addition, a major study of diffuse X-ray emission from the sky is in progress.

These scientific achievements have been made in face of a number of technical problems: spurious switching (probably due to ground-based interference) of several of the satellite's subsystems including experiment high voltage supplies and the on-board tape recorder; large temperature excursions particularly during periods of full Sunlight; a slow degradation of the battery performance which resulted in battery cut-outs with attendant long recovery periods and anomalies in the on-board attitude sensing system producing significant errors in pointing. In spite of these difficulties, Ariel 6 has been kept operational largely by the concentrated effort of all concerned in overcoming the problems and by the use of additional NASA ground stations, a portable ground station set up by University College London near Canberra in Australia, and the Italian San Marco Station in Kenya.

The satellite has continued to accumulate good scientific data. Indeed, the project has twice been extended beyond its nominal two-year mission. Since late June it has been operated using only the RAL ground station and the portable ground station at Canberra.

Deke Slayton during training for the Apollo Soyuz mission.

NASA

SLAYTON LEAVES NASA

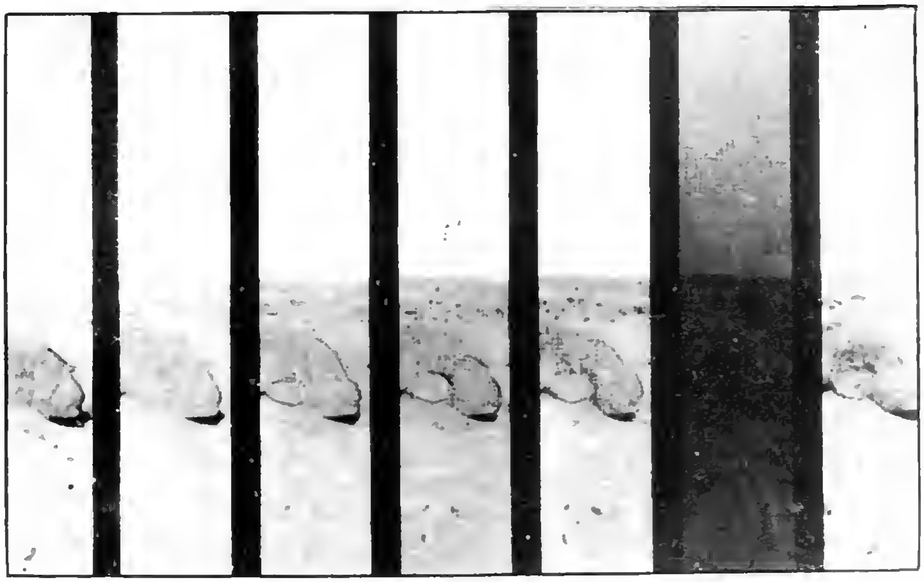
Donald K. "Deke" Slayton, 58, manager for the Orbital Flight Tests of the Space Shuttle, will leave NASA on 1 March after 23 years with the space agency. Slayton is the last of the original seven Mercury astronauts to retire. He retired from NASA in February 1981, but stayed on the job on a temporary appointment as a rehired annuitant. He will serve as a consultant to the Aerospace Corporation of El Segundo and to Space Sciences, Inc., of Houston.

Slayton said of his two decades with the space programme, "There's nothing I'd rather have been doing. But this new phase of my career looks like it also should lead to constructive, enjoyable work."

Grounded from space flight in August 1959 because of a suspected heart condition, Slayton later flew as part of the American crew in the July 1975 Apollo Soyuz joint space rendezvous and docking mission.

While grounded, Slayton served as head of the Astronaut Office and Director of Flight Crew Operations at the Johnson Space Center. He resigned from the Air Force in 1963 and joined NASA. He was manager for the approach and landing tests with Shuttle Orbiter *Enterprise* from 1975 to 1977, and in 1977 he was named to manage the four-mission Orbital Flight Test programme with Orbiter *Columbia* to bring the Shuttle Space Transportation System to operational readiness.

Slayton joined the Air Force in 1942 as an aviation cadet and flew 56 combat missions in Europe and seven over Japan as a B-25 bomber pilot. He was a test pilot at the Air Force Test Pilot School at Edwards Air Force Base in California, when he was selected as a Mercury astronaut. He has logged more than 7,000 hours flying time, most of which is in jet aircraft, and holds a bachelor's degree in aeronautical engineering from the University of Minnesota.



These pictures, returned by Viking Lander 1 over a 1½ Earth year period, show a small section of the surrounding area before, during and after a dust storm. The sixth frame, taken on 14 June 1981, shows the storm in progress and almost obscuring the "Big Joe" boulder. The brightness variation on the other images is caused by the changing Sun angle. It is hoped that Lander 1 will continue to return periodic data until at least 1994.

NASA

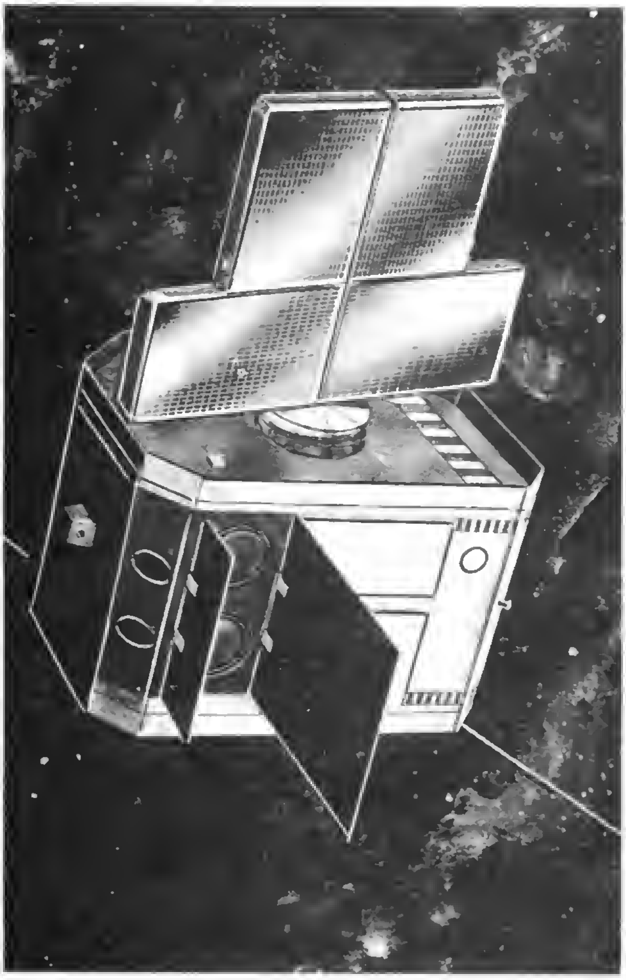
STS-5 PAYLOADS

The US space communications company Satellite Business Systems expects its third spacecraft to enter orbit in November aboard STS-5, the first operational mission of the Shuttle system. Telesat of Canada has committed a satellite to the same mission.

The importance of using a reusable launching system can be appreciated by looking at the cost differences between this launch and previous SBS flights. The company paid NASA $23 million for each of two Delta launches and related services, but the Shuttle's ride into orbit will cost about $8 million, according to Lawrence A. Weekley of SBS.

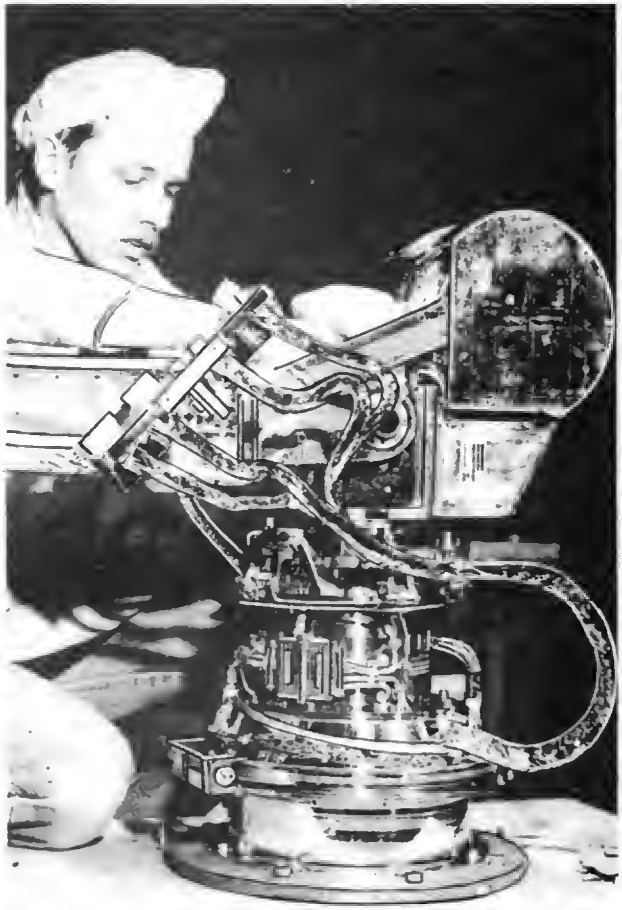
"Our spacecraft are designed to launch via Delta or the Shuttle," Weekley explained. "The dual launch compatibility is achieved with a payload assist module (PAM) which acts as a third stage. It is integrated into our spacecraft payload. We procure PAM as part of our spacecraft contract with Hughes Aircraft Co. Hughes subcontracts with McDonnell Douglas for PAM manufacture. For either Delta or Shuttle, SBS opted to contract with NASA for launch into synchronous transfer orbit; we assume responsibility for PAM and apogee motor manoeuvres."

Weekley denied published rumours that his company plans to use the European Ariane for any future launch. The Federal Communications Commission recently authorised SBS to complete negotiations for communications service to Canada.



Exosat, Europe's new X-ray astronomical satellite is due for launch by Ariane from Kourou in South America this October.

MBB



British Aerospace have completed development of the Space Telescope's solar array. The section shown here is the Primary Arm Deployment Mechanism. The array will carry 48,760 solar cells to provide power for experiments, control and data systems. Launch is scheduled for 1985 aboard the Shuttle.

BAe

ASTRONAUT APPOINTMENT

Astronaut Dr. Joseph P. Kerwin has been appointed by NASA to assume duties as the agency's Senior Scientific Representative in Australia effective in April 1982. Upon conclusion of this two-year assignment, he will return to the Astronaut Office at the Johnson Space Center in Houston.

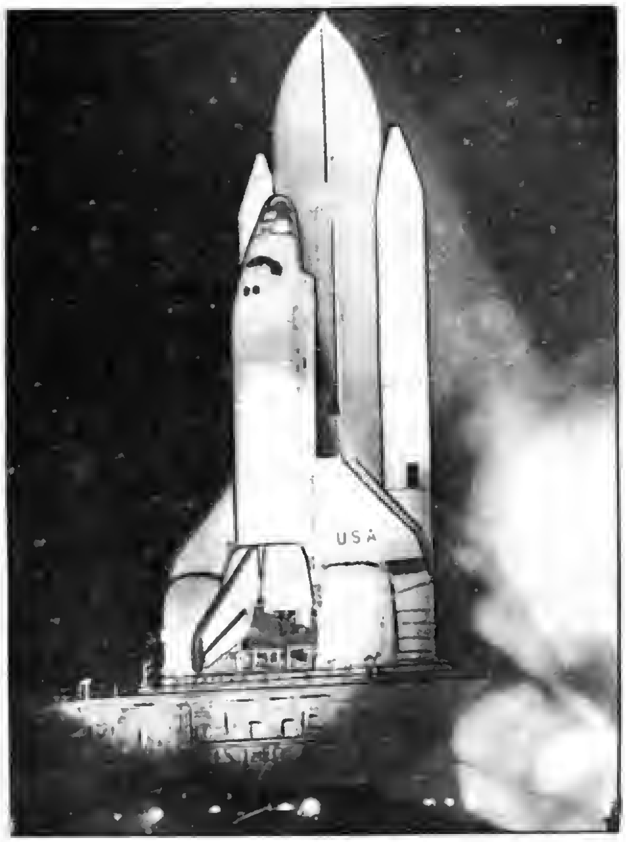
Kerwin will report to Robert E. Smylie, NASA Associate Administrator for Space Tracking and Data Systems, and will act as liaison between that office and Australia's Department of Science and Technology.

NASA has had a representative in Australia for almost 20 years. Two NASA tracking stations (at Yarragadee and Orroral Valley) support Space Shuttle operations by providing voice contact and data acquisition and relay. Another tracking station near Canberra is used to track deep space probes.

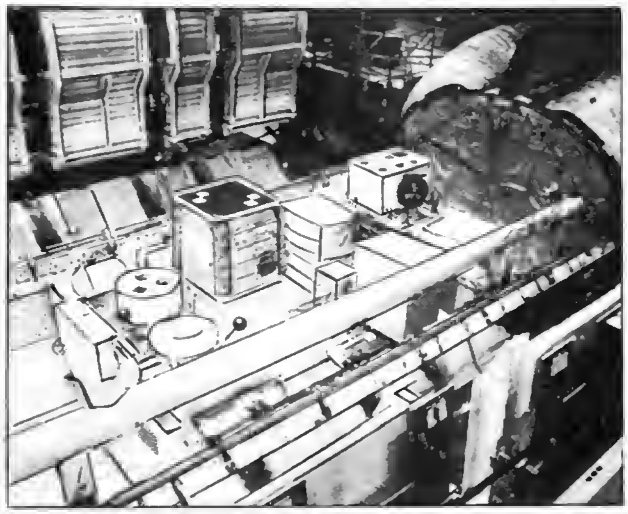
Kerwin's responsibility will be to coordinate NASA tracking requirements with the Australian government and assure its awareness of NASA's plans in space.

FIFTH ORBITER

NASA officials are pressing Congress to authorise a fifth Orbiter, originally deleted from the programme by President Carter. Dr. Stanley Weiss told a House subcommittee that the agency plans 70 flights through to September 1987. Communications satellites are the most numerous, followed by military



Columbia waits for launch to begin the third Shuttle orbital mission from the Kennedy Space Center.
NASA



Top: technicians spray water-proofing onto *Columbia*'s underside to prevent the thermal tiles from absorbing moisture. *Above*: the OSS-1 experiments package and Development Flight Instrumentation (towards the rear).
NASA

payloads, scientific spacecraft and Spacelab.

Major General James Abrahamson, new Shuttle director, said that 24 launches per year are planned by 1988. That volume would stretch the capability of a four-Orbiter fleet. A second vehicle, *Challenger*, will reach Kennedy Space Center in June; *Discovery* is due in September 1983 and *Atlantis* in December 1984.

INSTRUMENT TESTING

Testing 24,000 instruments to ensure that they meet Federal Bureau of Standards specifications will cost $2,593,747 in the next 12 months. The Kennedy Space Center extended its contract with the Bionetics Corporation for standards and calibration support, increasing the total Bionetics contract to $11,518,616.

ORBIT RECEPTION SYSTEM

The London Science Museum now has an "Orbit 137" system for receiving images from such meteorological satellites as NOAA, Meteosat, GMS and GOES, writes Nicholas Steggall.

The system is a relatively cheap method of obtaining weather pictures. It consists of an antenna, VHF-Receiver, APT-Processor, Digital-storage and a Video monitor. It can be used for receiving polar-orbiting satellite images although additional equipment of a parabolic antenna and S-band converter are required for geostationary satellites.

The system can be extended by introducing a laser-fax recorder to provide hard copy.

IN THE PAST

25 Years Ago ...
11 June 1957 First launch of the Atlas missile ended in an explosion some 10,000 ft above the ground.

20 Years Ago ...
26 May 1962 The F-1 engine, destined for use on the first stage of the Saturn 5 Moonrocket, was fired for the first time at full power.

15 Years Ago ...
12/14 June 1967 The Soviets launched Venera 4 and the Americans Mariner 5. Venera 4 dropped a capsule towards the planet's surface on 18 October.

10 Years Ago ...
26 May 1972 Wernher von Braun announced his retirement from NASA after 12 years with the agency.

5 Years Ago ...
17 May 1977 A seven day Spacelab simulation at the Johnson Space Center ended.

D. J. SHAYLER

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DISCO – EUROPE'S SOLAR ASTRONOMICAL SATELLITE

By Andrew Thomson

The January and March issues of *Spaceflight* carried reviews of the proposed Asterex and Kepler projects of the European Space Agency. Here, Andrew Thomson describes the proposed DISCO solar observatory.

ESA, of course, are studying other projects with a view to selecting one or more for further work. By the end of 1980, seven proposals had been received, four of which were selected by the Astronomy and Solar Working Groups for further study. These were Magellan (ultraviolet observatory), Kepler (Mars orbiter), Asterex (asteroid probe) and DISCO.

The results of ESA's own assessments of these missions vere presented to their Science Advisory Committee last June, with the result that Magellan and Kepler were selected for Phase A studies, Asterex was dropped for the time being and DISCO was recommended for further study with a revised scientific objective. DISCO was recommended for Phase A study after the reassessment was completed last November.

The Magellan, Kepler and DISCO proposals thus joined those of X-80 and ISO to go forward for possible selection at the end of this year. The 1,100 kg X-80 satellite is designed to study high-energy X-rays with five instruments over the energy range 0.5-200 keV. ISO (Infrared Space Observatory) consists of a 60 cm diameter telescope mirror cooled by liquid hydrogen and helium for making precise observations in the 1-150 μm infrared band.

Introduction

DISCO (Dual Spectral Irradiance and Solar Constant Orbiter) is designed to study:

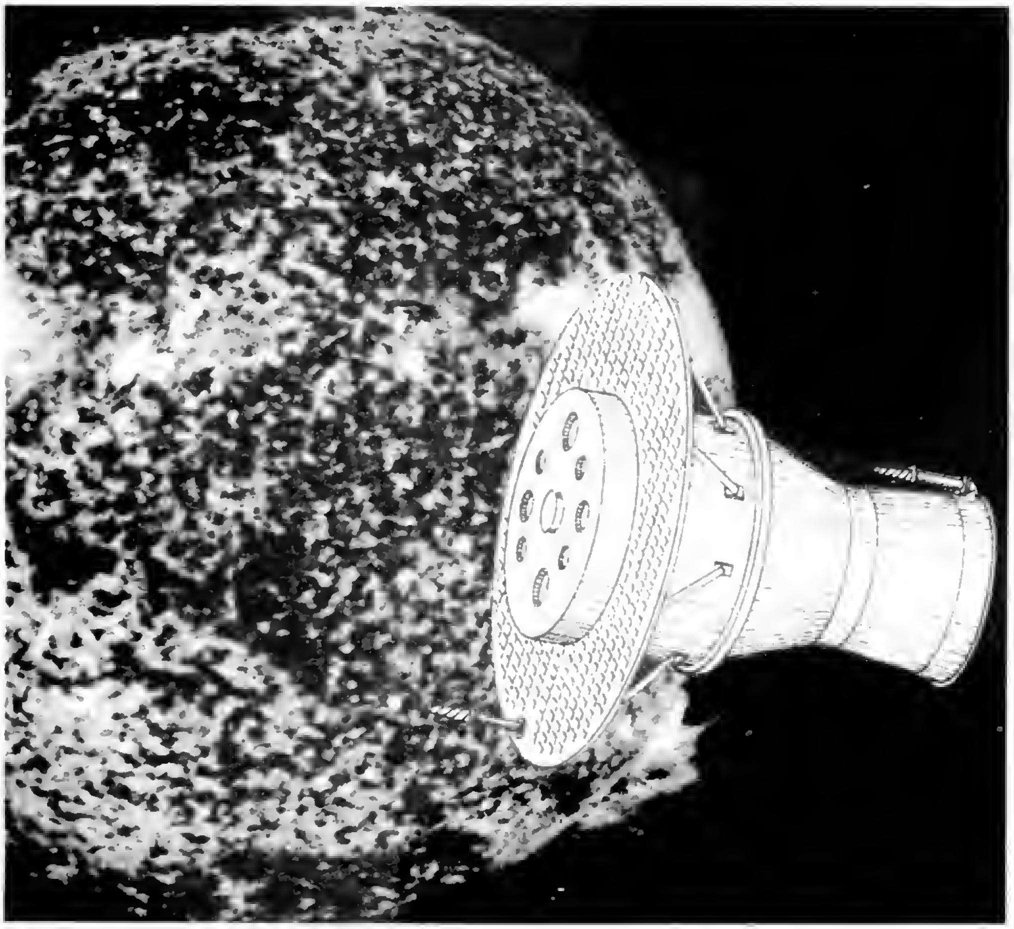
1. The variability of the global oscillations of the Sun in visible light;
2. The variability of the total irradiance at Earth's orbit (the "solar constant");
3. The variability of spectral irradiance in the ultraviolet, visible and infrared.

"Irradiance" is the received radiation from the Sun at the Earth's orbit ("illuminance" or "illumination" is the equivalent word for visible light). DISCO will measure both the total radiant output received across the whole electromagnetic spectrum (total irradiance), together with the radiant output in one or more specific parts of the spectrum (spectral irradiance – DISCO has the capability to measure this in ultraviolet, visible light, and infrared).

DISCO's continuous observations over six years should allow progress to be made in two main areas:

Investigation of the Solar Interior

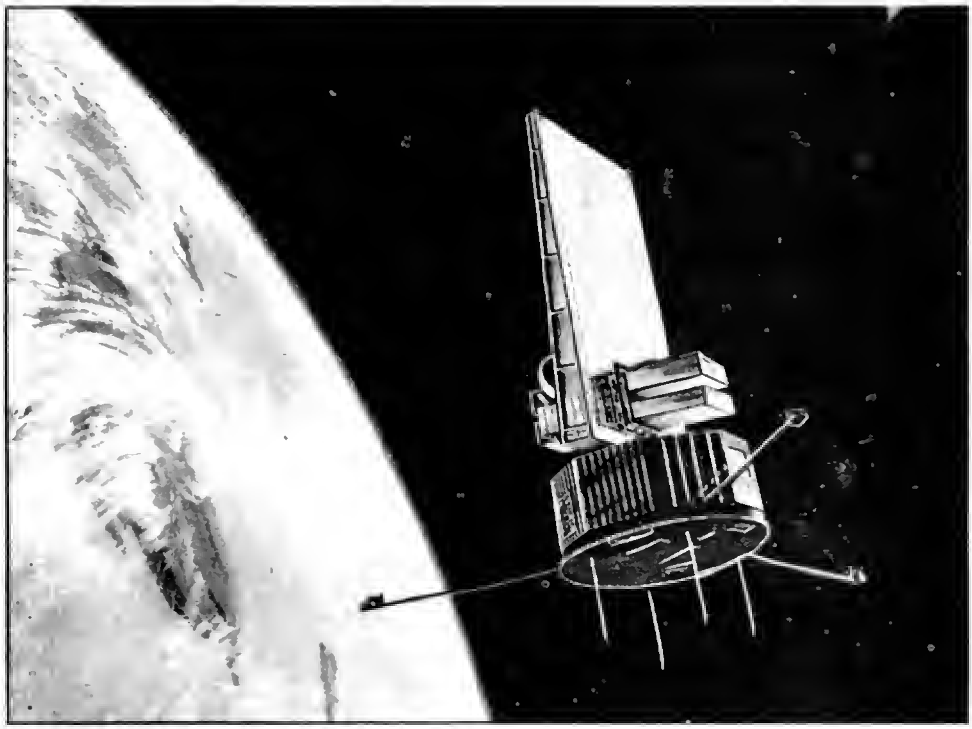
Measurements of the global solar oscillations and irradiance, and their variations, will enable a concise investigation of the physical properties and dynamics of the Sun's interior to be made. Global oscillations will provide information on the behaviour of the Sun from the surface down to the centre. Long-term monitoring of the total irradiance will provide essential information for understanding the dynamics of the



DISCO is basically a cylinder with a disc of solar cells attached. The illustration shows the instruments viewing through the end of the cylinder, with an S-band communications antenna in the centre. The omnidirectional antenna on the solar disc is used mainly for maintaining contact before final orbit is achieved.

The boost motor and its adapter separate after burn-out (in the plane just beyond the bottom of the struts).

ESA



The American Orbiting Solar Observatory (OSO) series of astronomical satellites have a long record of Sun-watching. This version carried a spinning base (for stabilisation) and a solar panel with instruments locked on to the Sun.

NASA

11-year solar cycle. With its lifetime of six years DISCO will not be able to cover a complete cycle, but it will prove that long-term measurements are possible, leading the way to a much longer-term investigation in the future.

Relevance to Earth's Atmospheric Processes

Several authors have made claims of a connection between a variable Sun and the Earth's climate. There are a host of ingenious ideas ranging from decreased solar radiation caused by black spots on the Sun, through cosmic ray flux changes, cosmic dust clouds, movement of the Earth's magnetic field, or conjunctions of the planets, to solar ultraviolet effects on the ozone layer. To create some order in this chaos it is necessary to establish whether or not there is a variation in the solar radiation, and if there is, we need to find its magnitude, spectral distribution and period. DISCO is designed to do just this.

The Payload

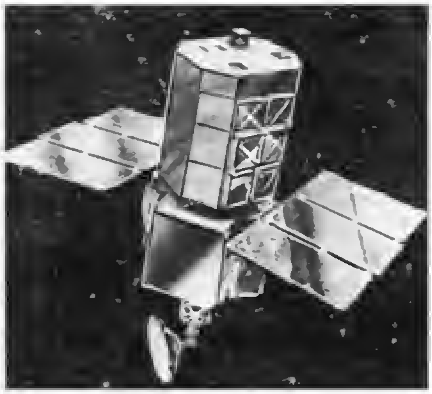
The model payload for DISCO includes: two pyrheliometers to measure the intensity of the Sun's radiant energy; a far-UV spectrometer to observe radiation originating from the solar chromosphere and corona; photometers to measure spectral irradiance at several fixed wavelengths (one each for UV, visible and IR); and a high-resolution spectrometer to measure and resolve small amplitude pulsations. Most of these instruments already exist; some have already flown on rockets and balloons or will be placed aboard Spacelab. (One version of the high-resolution spectrometer has been operating on the ground, at the South Pole, and needs to be adapted to the satellite conditions).

Continuous observations (as opposed to "snapshots") are crucial to DISCO's mission. However, continuous monitoring with the required precision over more than six years is a difficult problem and requires a very careful and systematic approach. The obstacles are the intrinsic limitations of the detectors and the degradation of the photometric properties of the instruments once in orbit. To retain the required accuracy over DISCO's lifetime the properties of the instruments will be continuously monitored using in-flight calibration standards. Periodic flights of balloon-, rocket- and Shuttle-borne instruments will produce frequent accurate recalibration of the spacecraft instruments.

The experiment payload and the various subsystems are housed inside a cylindrical structure 1.2 m in diameter and 0.8 m long. The spacecraft is spin stabilized with the main axis pointed to the Sun. There is a fixed (non-deployable) solar array on a circular platform of 2.4 m external diameter. Total cell area is 3 m^2, sufficient to meet the planned power requirements of 265 watts (peak). Telecommunications use the standard S-band; in the operational phase only one ESA ground station is necessary. Data will be acquired from Villafranca, Spain or Odenwald, Germany for about 8 hours each day. Spacecraft and payload operations will be controlled from ESOC, Darmstadt.

ESRO/ESA scientific spacecraft launched to date.

	Launch date	Mission
ESRO-II	17 May 1968	Cosmic rays, solar X-rays
ESRO-IA	3 October 1968	Auroral and polar-cap phenomena ionosphere
HEOS-1	3 December 1968	Interplanetary medium, bow shock
ESRO-IB	1 October 1969	As ESRO-IA
HEOS-2	31 January 1972	Polar magnetosphere, interplanetary medium
TD-1	12 March 1972	Astronomy (UV, X- and gamma-ray)
ESRO-IV	22 November 1972	Neutral atmosphere, ionosphere, auroral particles
Cos-B	9 August 1975	Gamma-ray astronomy
Geos-1	20 April 1977	Dynamics of the magnetosphere
ISEE-2	22 October 1977	Sun/Earth relations and magnetosphere
IUE	26 January 1978	Ultraviolet astronomy
Geos-2	14 July 1978	Magnetospheric fields, waves and particles



Far left: a striking view of the solar corona provided by the Solar Maximum Mission satellite. *Left:* the malfunctioning SMM satellite may be repaired in orbit during a Shuttle mission.

NASA

The Orbit

DISCO will orbit near Lagrangian libration point L1 (or L2), constantly on the Earth-Sun line, 1.5 million km from Earth. Here, the Sun is permanently visible from the spacecraft without eclipses, and the radial velocity with respect to the Sun is very low (a requirement of the high-resolution spectrometer). An orbit close to L1 has been recently flown by NASA's International Sun-Earth Explorer 3 spacecraft.

Launch will be by Ariane 2 or 3, using the SYLDA dual-launch facility (ample mass is available for a second passenger). After launch, DISCO will follow the "standard" Ariane procedure of injection into an intermediate geostationary transfer orbit. At perigee of this intermediate orbit, a solid boost motor inserts DISCO into a cruise orbit towards L1. To reduce outgassing contamination on the scientific instruments, the boost motor is ejected after burn-out. The motor, propellant and attachment casing account for just over one-third of the total spacecraft weight at launch of approximately 900 kg. Transfer to L1 (or L2) will take about 120 days, following which onboard hydrazine thrusters will be used for final orbit insertion.

Conclusions

ESA's space science projects presently include:

- Exosat – X-ray observatory (1982);
- Giotto – probe to Halley's Comet (1985);
- Space Telescope – ESA developing Faint Object Camera, solar arrays (1985);
- Hipparchos – astrometry satellite: to measure position and motion of 100,000 selected starts (1986);
- Solar Polar Mission – probe to fly over Sun's unobserved polar regions (1986?).

Until recently many feared that following the great successes of the first decade of ESRO/ESA science satellites, European space science research would enter something of an eclipse because of constricted budgets and competition from applications projects. The projects before ESA in 1982 show that the enthusiasm and breadth of new ideas is still there.

TOWARDS AN INTERNATIONAL SPACE CO-OPERATION AGENCY

By Steven K. Hurst

In the November 1981 issue of *Spaceflight* we published the article "On the Formation of a Global Space Agency" which put a case forward for world-wide co-operation in space projects.

In response to that suggestion, the article below argues that such an Agency is not politically feasible at present but, instead, we should aim for a collaboration of the various national agencies.

Introduction

The most important question to ask when considering the formation of any international organisation is "Why is this better done at international level than at national or even local level?"

When more than one country becomes involved in an organisation, the scope for disagreement multiplies geometrically. It can lead to a general lack of responsibility. The European Space Agency (ESA) shows that co-operation in an international research body is feasible. However, it could be argued that the Ariane launcher is successful only because, in practice, it is the responsibility of a single member state. The previous efforts of ELDO, whose launcher consisted of stages manufactured by different countries, were conspicuously unsuccessful.

It is thus important that the formation of any kind of global space agency should be a carefully-tailored response to a specific and generally-agreed set of needs. In order to identify the possible areas of need for such an organisation, it is necessary first to examine those activities which, for better or worse, are going to remain at the national level. It is also necessary to distinguish between the differences in co-operation over research into the space environment using existing technologies, over research into space technology itself, and over the commercial use of space. The problems and opportunities are quite different.

The Military Aspect

Firstly, military activity is going to remain at the national level. No existing or aspiring space power is likely to give up

News from the Cape/contd.

ASTRONOMY PROPOSALS

Working groups sponsored by the Marshall Space Flight Center are considering two proposed solar science instruments: a solar beacon and a pinhole occulter facility. Each group consists of solar physicists and astronomers from American and foreign universities, observatories and government agencies.

The beacon involves a flat mirror of 1-2 m flown to geosynchronous orbit to trap solar rays and reflect them to Earth, possibly to the Arizona desert, projecting an image 350 km wide. Monitoring stations at opposite edges of the reflection would measure the Sun's diameter. The mirror would oscillate, thereby moving the reflection, permitting several tracking stations to measure the intensity along a line in the image.

Max Nein, NASA representative to the working group, commented that "We know the Sun's diameter shifts because of internal effects. We'd like to study that phenomenon more closely. We'd also like to study relationships of the Sun's changing diameter with its rotation and pulsations as well as their effects on climatic conditions."

The pinhole facility is a module proposed for Shuttle launch in the late 1980's. A large mask would extend from a 50 m boom carried in the cargo bay, blocking out the solar disc to allow study of the corona. Joseph Dabbs, secretary of a group, said "We'd use a visible light coronograph and ultraviolet spectrometer with imaging proportional counters to produce corona images."

The occulter mask would be rounded at one corner to permit 90-degree viewing of the corona. "We would rotate the mask for full-circle study at any time," Dabbs said. He believes the experiment should be flown at a time of maximum solar actively, indicating a possible 1990 shuttle launch.

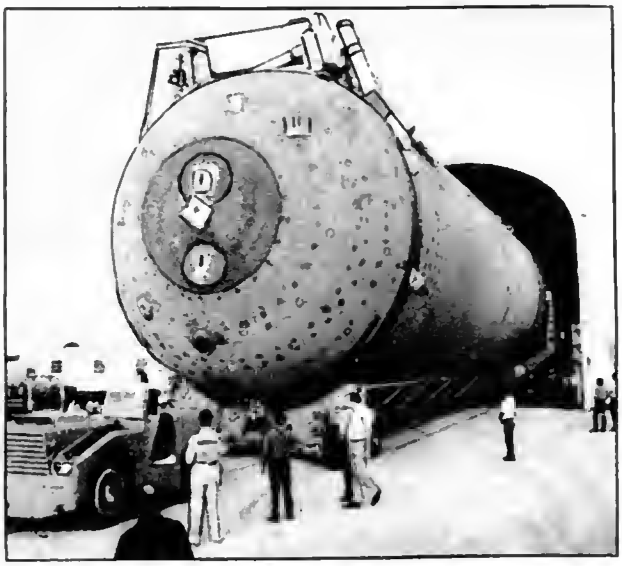
STS-3 astronauts Gordon Fullerton (left) and Jack Lousma prior to boarding *Columbia* for a simulated countdown and lift off in February.

NASA

SHUTTLE FACILITIES

More Shuttle facilities costing $13 million will be constructed at Kennedy Space Center to support up to 20 launches per year (briefly mentioned in May's "News From The Cape"). That is half the maximum rate NASA anticipated when development began 10 years ago.

A third firing room will be equipped in the Launch Control Center for military missions requiring additional security. The first Shuttle-borne military satellite is scheduled to fly aboard *Columbia* in July.



The External Tank for the fourth Shuttle orbital mission arrived by barge at the Kennedy Space Center in late January.

NASA

A new complex will be built north of the huge Vehicle Assembly Building to process and store solid booster segments. Each of the two boosters consists of four segments containing a total of 1,110,290 lb of high energy propellant. Segments are presently assembled in the VAB, creating a hazardous environment that affects other Shuttle work.

The complex consists of a main structure 100 ft tall, known as the Rotation/Processing Facility, a support building and two storage buildings. They can store two sets of boosters at a time. Two 200 ton cranes will be installed in the larger structure.

A second bay is being built in the Orbiter Processing Facility to cope with the delivery of *Challenger*, second of the shuttle fleet, in June. Another mobile launcher retained from the Apollo programme will be refitted for Shuttles.

Two more high bays in the VAB will be equipped to accommodate Shuttles during vertical mating of the Orbiter, propellant tank and solid boosters.

KSC expects to modify Pad B at Launch Complex 39 for future Shuttle launches by 1986. Until then Pad A remains the only complex that can accommodate the vehicle.

Related projects completed in 1981 included a Vertical Processing Facility in the centre's industrial area and a Life Sciences Facility in a Cape Canaveral hangar. The former made use of a building created for the Mars Viking project. It will be used for payloads that must be stacked vertically, such as communications satellites and their boost motors. Two of these satellites will be carried in STS-5 in November. The sciences facility is a holding and preparation area for plants and animals to be flown in Shuttle experiments.

INMARSAT SYSTEM INAUGURATED

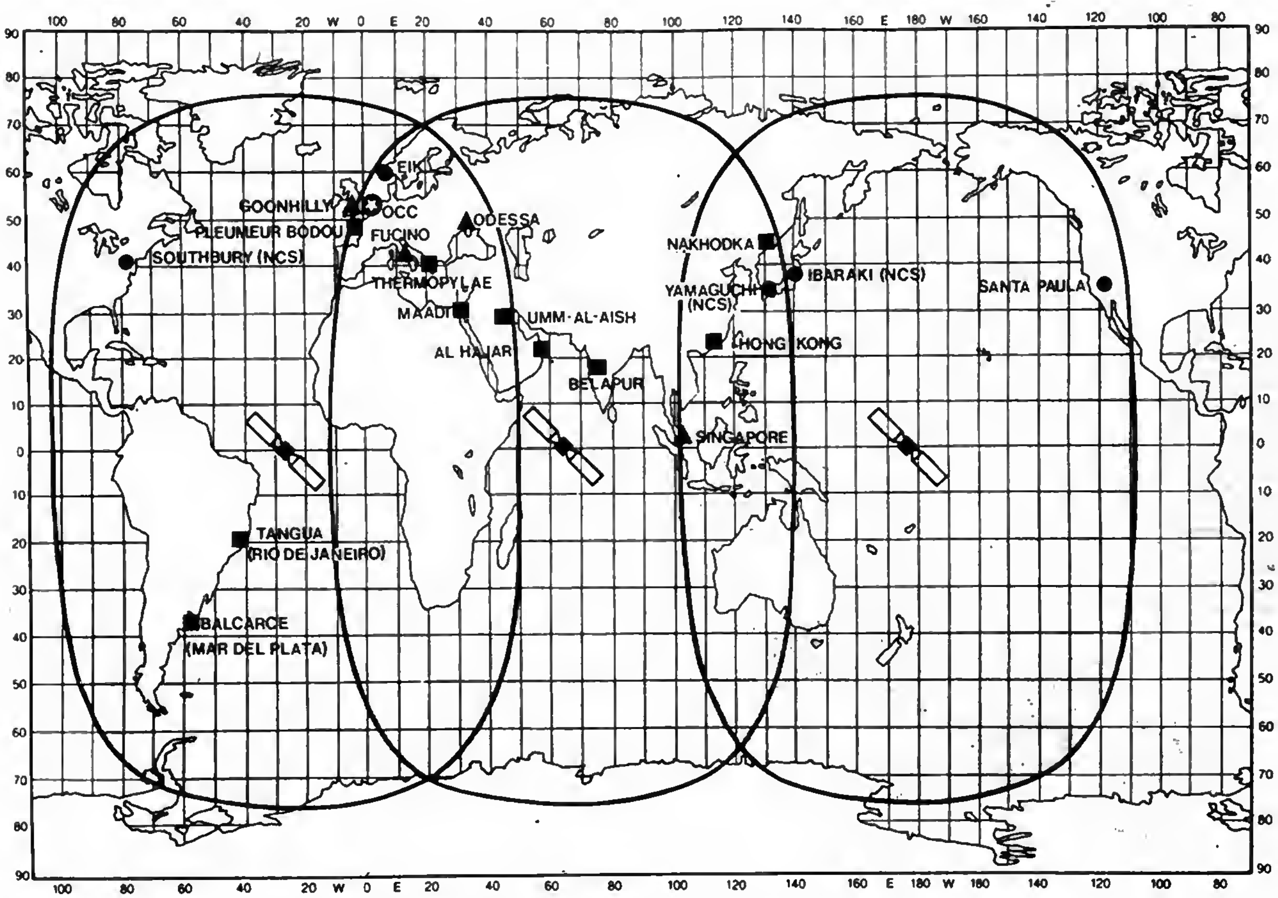
On 1 February the Inmarsat (International Maritime Satellite Organization) satellite system officially came into operation. The ceremony was marked by demonstrations of communications with three ships in three separate far-distant oceans and time zones. One was the Queen Elizabeth II, then 480 km south-east of Rio de Janeiro. The guest of honour, who performed the official inaugeration was, appropriately enough, Marchesa Maria Cristina Marconi, widow of Guglielmo Marconi.

Inmarsat came into being on 16 July 1979 after a series of international conferences arranged by, amongst others, the UN agency IMCO (International Maritime Consultative Organisation). This defined the need for a satellite-based maritime communications system. Since 1976 COMSAT had been running the MARISAT satellite system using three US-built satellites above the Atlantic, Pacific and Indian Oceans. Besides taking over this service, Inmarsat will soon have further capacity in the form of leased capacity on two MARECS satellites and three Intelsat V's with purpose built MCS (Maritime Communications Systems) modules. The first MARECS was launched by Ariane on 20 December 1981 and was due to be handed over in March 1982 after check-out. The second was due for launch in April, with the first of the Intelsat V capacity becoming available soon after.

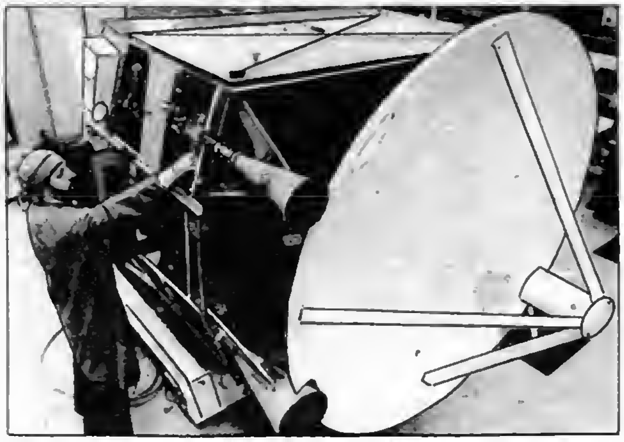
Inmarsat takes over at a time when 1,000 ships have installed satellite antennae. It is estimated that 70,000 vessels are of a sufficient size to benefit from such a system. Oil rigs, liners and merchant shipping will be the main customers, though there are some large private yachts that have been able to afford the $60,000 or so for the ship terminal. Apart from an emergency service and a radio telephone service, Inmarsat sees one of its most important uses being in ship management.

Apart from the satellite segment, Inmarsat also manages the land-based network that supports the system. This consists of the Coast Earth Stations (CES) which are owned and operated

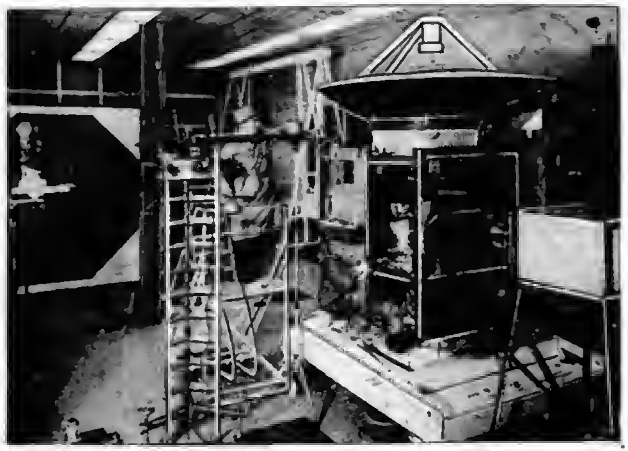
The Inmarsat system was inaugurated by Marchesa Marconi (centre) and her daughter Princess Elettra. At left is Inmarsat's Director General, Olof Lundberg. The BIS was represented at the opening by *Spaceflight* editors Andy Wilson and Alan Farmer.



Inmarsat global coverage. See also news item headed "New Satellite Station".



Above and below: preparing a MARECS maritime communications satellite for launch. Launch of the second satellite of the series has been delayed by about two months from the original date of 23 April.



by the signatories to the Inmarsat agreement, but coordinated by the organisation. The CES's are regionally coordinated via Network Coordination Stations which in turn are linked through the Operations Control Centre in London.

At the time of the inaugeration there were 37 members of Inmarsat with Sri Lanka the latest signatory on 15 December 1981. The system already handles about ¾ million minutes of telephone and 1½ million minutes of telex traffic a year. Oil tankers are the greatest users (42 per cent) and cargo/container ships the next (24 per cent). The Soviet Union is one of the major signatories (with 14 per cent investment share it is second only to the USA). So far only nine Soviet ships, using Japanese and American technology, are equipped with ship Earth stations. The further spread of terminals has been stopped until the USSR can supply its own ship-based terminals, though it is claimed Soviet shipping companies will then be free to choose equipment from any source. So far all space-based equipment is leased from Western organisations but a feasibility study is in hand for equipping some Molniya satellites for maritime use. They have the advantage that their elliptical polar orbits cover higher latitudes than the geostationary satellites currently used. That poses other problems in terms of tracking the satellites from shipboard. The current system does not use active tracking – the shipboard terminals are locked on to a selected position provided by Inmarsat for each of the ocean regions.

Nevertheless Inmarsat is unlike other international communications satellite bodies in having large Soviet involvement and it will be interesting to see what mixing of East-West space technologies takes place, and what sort of competition this will lead to in the long term.

NEW SATELLITE STATION

Europe's first coast Earth station for maritime satellite communications was inaugurated on 22 February at Eik, southwest Norway.

Eik is the fifth coast Earth station in the global satellite system introduced on 1 February by the International Maritime Satellite Organization (Inmarsat). The others are at Ibaraki and Yamaguchi in Japan, and Santa Paula and Southbury in the USA. Another 14 new coast Earth stations are planned to come into operation before 1984, making 19 in all.

Eik's geographical position, in the overlap area of geostationary satellites above the Atlantic and Indian Oceans, enables it to serve either region. Initially it will handle calls for the Atlantic, but later this year it will be switched to the Indian Ocean, after another new coast Earth station (Goonhilly) takes over the Atlantic service.

Opening of the Eik station dramatically shortens the terrestrial links needed for telephone and telex calls by satellite between Europe and ships in the Atlantic. At present, these have to go via the Southbury station on the east coast of the USA.

WESTAR IV LAUNCHED

The Westar IV communications satellite was launched by Delta 160 from Cape Canaveral on 26 February.

The Hughes-built Westar IV has a design life of 10 years and will relay voice, data, video and facsimile communications to the continental United States, Hawaii, Alaska, Puerto Rico and the Virgin Islands from a geosynchronous position of 99 degrees west longitude.

Westar I was positioned approximately on-line with San Antonio (Texas), at 99 degrees west longitude; Westar II is located on a line slightly west of San Francisco at 123.5 west longitude; and Westar III is positioned at 91 degrees west longitude. Westar I and II are expected to reach the end of their design lives in 1983 and 1984, respectively.

Westar IV and the planned Westar V, scheduled for launch in 1982, will relay communications traffic now carried by these two satellites. (See p. 205 of the August-September 1981 *Spaceflight* for details of the HS 376 communications satellites, of which the latest Westar is an example).

Westar IV is double the size of the earlier craft and has about four times the capacity. The satellite is 274 cm (108 in) high in its stowed configuration and 684 cm (269 in) tall when it is deployed for operation. Diameter is 216 cm (86 in). It weighed about 1,100 kg (2,425 lb) in transfer orbit after the Payload Assist Module of the Delta 3910 had burned out and approximately 585 kg (1,290 lb) in geosynchronous orbit after the Star 30 apogee kick motor had fired.

Westar IV carries 24 transponder channels and develops 40 per cent more transmitting power than most domestic communications satellites, producing in excess of 800 watts of solar power.

HOSPITAL SATELLITE SERVICE

The American Hospital Video Network plans to start transmitting medical educational programmes to subscribing hospitals throughout the United States towards the end of this year. Broadcasts were due to begin last March but problems in acquiring the equipment necessary for using the 12–14 GHz satellite link have forced the delay.

Dr. Leslie Norins, the Network's President, said that more than 1,300 of the 7,000 hospitals in the United States have expressed interest in the service.

THE MANNED ORBITING LABORATORY

PART THREE

By Curtis Peebles

In the April and June 1980 issues of *Spaceflight* the author described the US Air Force's plans for a manned Earth-observation platform. Here, he concludes the survey with a look at a model of the Manned Orbiting Laboratory.

The San Diego Model

One of the few artifacts from the Air Force's Manned Orbiting Laboratory programme is a 1/30 scale model in the collection of the San Diego Aerospace Museum. The historical importance of the model (which dates from mid-1967) is that it represents the final configuration and paint finish. At this time, although technical problems still remained, the design features had been by and large decided.

Unlike most desk models of the MOL, which are little more than cylinders topped by a Gemini, the San Diego model has extensive surface detail. At first glance, one is struck by the length: 27.6 in. (70.1 cm). This scales out to approximately 69 ft (21 m). The dimension in the original Presidential announcement was 54 ft (16.4 m), and 41 ft (12.8m) without the Gemini B. Brig.-Gen. Russell Berg, USAF (Ret), the model's donor, has confirmed its accuracy.

At the forward end is the Gemini B capsule, essentially a NASA Gemini with the addition of a hatch for transfer into the laboratory and a more hemispherical heat shield.

Originally, the Gemini B was to use 100 per cent oxygen. However, in late 1966, a decision was made to change to the oxygen/helium mixture that the laboratory used, a change recommended by the crewmen on grounds of fire safety. Gen. Berg received some criticism for this decision but it quieted down after the Apollo fire. The oxygen/helium atmosphere did, however, make the crew's voices high pitched and squeaky.

Behind the Gemini B capsule was the adapter section/laboratory interface. This black cone is 4.6 scale ft (1.4 m) long. Its sides are steeper than the NASA adapter and the forward end is actually smaller than the heat shield diameter, resulting in a step. The adapter carried six solid propellant retro-rockets; in addition to de-orbiting the Gemini B, they were also used in the event of a launch abort. The NASA Gemini/Titian II used ejector seats for pad escape but the more severe fireball of an exploding Titian IIIM prevented this for MOL.

There were four abort modes. Mode A was from on the pad to 30 seconds into the flight. The booster would be shut down, the six retros salvo-fired to effect separation from the laboratory and the crew would eject from the capsule. After 30 seconds, the booster was clear of land so ejection was not necessary.

Mode B covered from 30 seconds to 24,000 ft per second velocity (7,315 m/s). The booster would be shut down and, because of the high aerodynamic pressure, separation would be delayed by up to 16 seconds. Six, four or two retros would be fired, as needed. The adapter would then separate and a normal re-entry and splashdown be accomplished.

Mode C stretched from 24,000 fps (7,315 m/s) to 488 seconds flight time (± 20 seconds). The Gemini B would separate and fire its retros to reach the desired touchdown point at 40° south latitude.

Mode D would be an abort to orbit for a minimum of two revolutions. The MOL would be manually separated from the booster and use its thrusters to accelerate to orbital velocity. A degraded mission would be conducted to the extent possible.

The design fatality rates were three crews per 1,000 flights during launch, and one crew per thousand flights lost during orbit and re-entry [1].

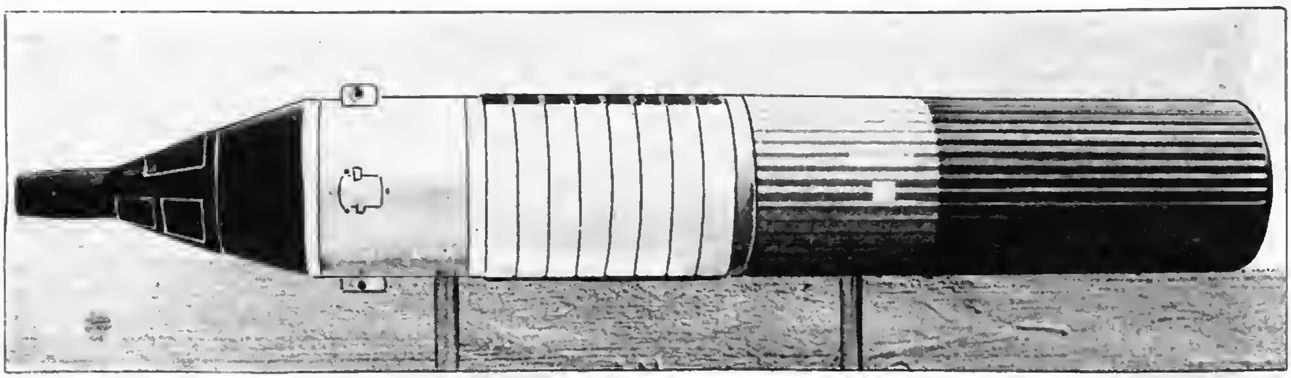
Behind the Gemini B is the forward compartment. It is natural metal in colour and 8.6 scale ft (2.6 m) in length from the forward white band to the white band at the laboratory. It contained the transfer tunnel, fuel cells, their cryogenic tanks and the thruster fuel tanks. The transfer tunnel was apparently one of the first technical details set; it had no other function than transfer. The separation sequence involved depressurizing the tunnel and firing linear charges to cut it at the Gemini B/MOL interface. The MOL used three fuel cells to supply power; these were fed from two large LH_2 tanks and a smaller LOX tank.

Attitude control was provided by four units, each with five thrusters. One pointed aft, one on each side and two pointed up. Each unit had its own separate fuel tanks.

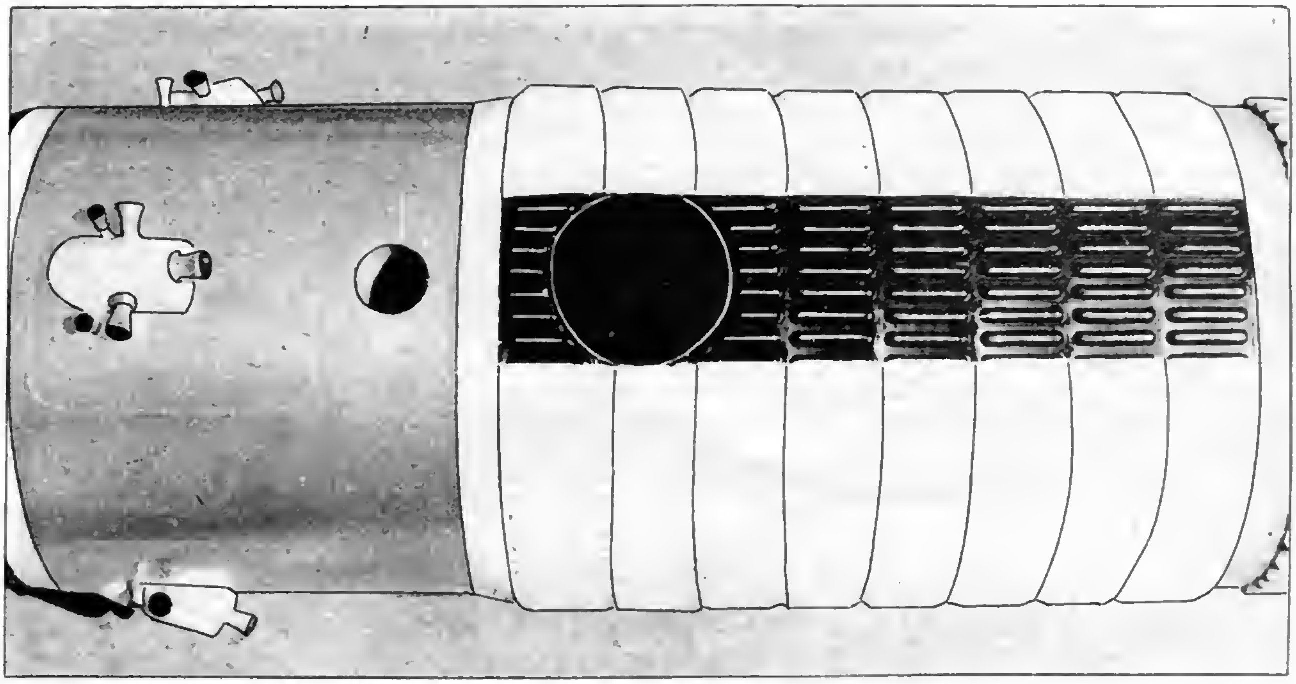
Further back is the laboratory; it is 15.1 scale ft (4.6 m) long. The outer skin bulges in this area, probably as a meteorite shield, and there are eight rows of stringers on its surface. The laboratory had no windows, it would have been like living in a submarine. The MOL astronauts, unlike the Skylab crews, could not sit by a window and watch the world go by.

The only interruption in the pattern is a 3 ft (0.91 m) diameter flat circle on the model's "underside". This is meant to represent an optical system, but as the MOL's normal orbital attitude was inverted the system would point out into space. An Earth-pointing system, therefore, should be on the "top" of the model or it would have had to be rolled before a photographic pass.

The laboratory is divided into two parts. The aft section (living quarters) included the dining area, the crew's sleeping



Sideview of the MOL model. The Gemini B is black with a white nose, the forward compartment is natural metal with white attitude control units. The pressurised laboratory section is white; the aft section is grey/black. The model was built in 1967 after the merger of McDonnell and Douglas.
C. L. Peebles



Underside of the MOL model. The 3 ft-diameter optical system is the only interruption in the stringer pattern. Unlike Skylab, there are no windows. The laboratory was divided into two with living and experiments sections.

C. L. Peebles

bags, an exercise bicycle and the waste management system. The forward section held the mission experiments. There was an up-and-down reference in the laboratory defined by the MOL horizontal. The floor ran the length of the laboratory and a wall served as a partition between the two areas. This was another request of the MOL crewmen - MOL was probably then ahead of the Apollo Applications Program (Skylab) in the area of habitability. Velcro carpets were tested as a method of keeping the astronauts anchored.

Completing the model is the equipment module. It is 29.5 scale ft (8.99 m) long and is painted grey and black. Stringers run down its length. There are two squares painted on each side of the model: the upper (larger) one is silver, the lower square is white. This section contained the tanks for the breathing gases. The aft tunnel, which appeared in the 1964 drawing in Part 2 of this series, did not survive. Comparisons of the 1964 drawings, the 1965 announcement and the 1967 model shows how the MOL changed.

The Gemini B adapter section lengthened somewhat from about 2 ft to almost 5 ft (0.14 to 1.5 m). The equipment module, also, grew several feet in length. The main difference between the 1964 drawings and the model is in the forward compartment. The earlier concept relied on solar arrays for electrical power. The Gemini B and laboratory were very close together. The use of fuel cells, however, required a separate area for the cryogenic tanks and related plumbing.

Management

Throughout the programme's life, both before and after approval, MOL was troubled by questions about the human factor. There were some, at the time, who doubted that the crew could survive for any lengthy period in space. The MOL team heard some dire forecast that a 30 day flight would soften the crew's skeletal structure. It was, also, not clear that Man's ability to make decisions and use his intelligence in space was worth the approximately $500 million necessary to include him in the system. This was always to remain a critical question, especially in light of Defense Secretary Robert McNamara's "show me" attitude toward manned military space missions. The Aerospace Corporation made numerous studies of experiments and roles of manned military operations, beginning in 1960 and continuing right up to the cancellation. It was to be a continuing debate on the exact role of Man and the degree of crew participation.

In the spring of 1966, an automatic operation mode was requested which added about 2,000 lb (907 kg) to the vehicle [2]. Given these conditions, MOL, as a manned space vehicle, could easily have been questioned and analysed into oblivion.

Full credit for getting the programme approved should go to Gen. Bernard A. Schriever. He maintained very good relations with, and the support of, key members of Congress. Through this he was able to convince them of MOL's importance, but doubts still lingered.

After approval, Gen. Schriever, who was also the Commander of Air Force Systems Command, was named as the first Program Director with responsibility for the broad overview. Also on that first MOL team was Maj.-Gen. Harry Evans, the Vice Program Director. His offices were in the Pentagon and his duties included the political aspects of MOL (relations with Congress and the White House, preparing briefings and appearing at budget hearings) and the programme interface with DOD. Brig.-Gen. Russell Berg, who was stationed on the West coast, was Deputy Program Director and handled the engineering of MOL. Scientific Advisor, from the Aerospace Corporation, was Dr. Peter Leonard. Members of the group communicated daily on all aspects of the programme and in addition would meet several times a month. They would also meet once a month with a Pentagon group composed of the Secretary and Under Secretary of the Air Force, the Assistant Secretary for Research and Development, the USAF Chief of Staff, and the Commander of the Air Force Systems Command.

The job facing them was hectic, difficult and required long hours. One example illustrates this. In September 1966 it was necessary to modify the baseline MOL configuration to meet the launch safety criteria. The cryogenic tanks required protection from the retro rocket blast in the event of a launch abort. Without it, an explosion was inevitable. The resulting

shrapnel and over-pressure would cause the Gemini B to tumble and re-contact the vehicle.

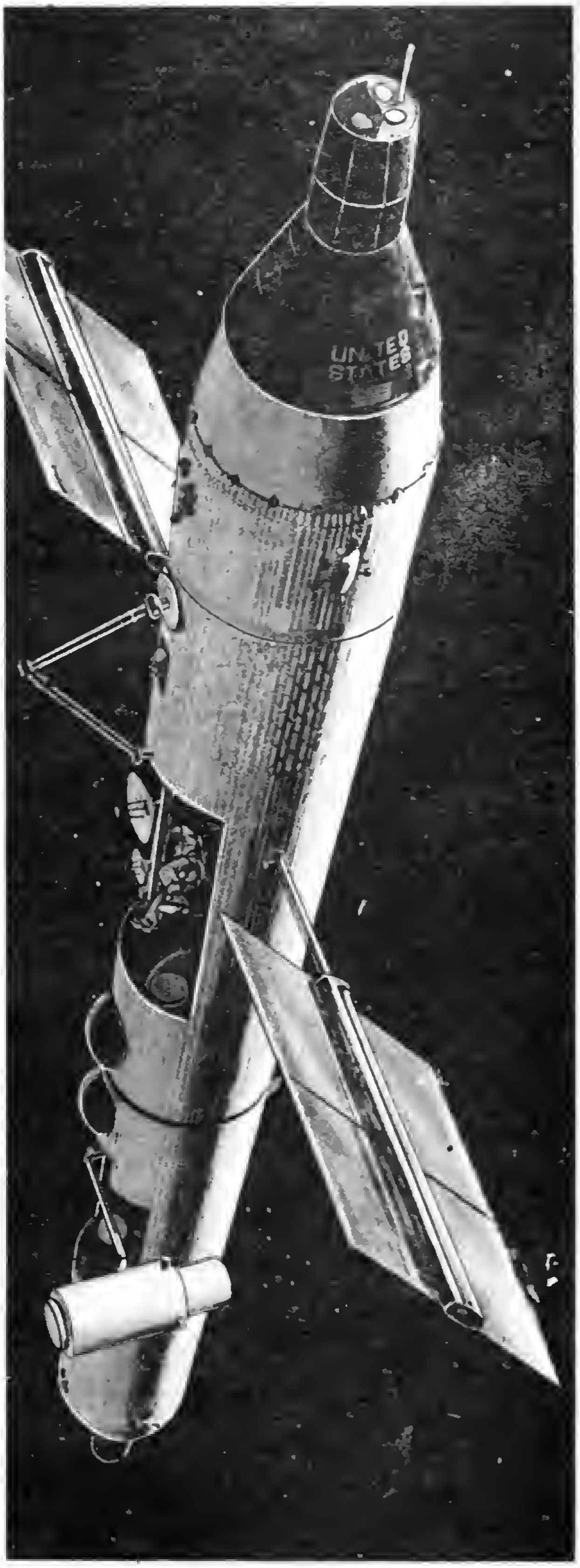
There were five options, including a launch escape tower, an alternative eliminated early due to the cost, technical risks, weight and effects on the Gemini B, laboratory and the Titian IIIM. The others were local blast protection on the cryogenic tanks in the forward compartment; local blast protection and a thrust vector control (TVC) gas generator on the Gemini B; a full blast shield (a dome at the Gemini B/Lab interface) and a full blast shield and TVC. Each met the requirements. It was then necessary to weigh their strengths and weaknesses. Local blast protection had the lowest weight and cost but contributed nothing to pad escape capabilities. It had only minimal high dynamic pressure abort capacity and required venting of the adapter. Adding TVC increased weight, cost and complexity but maximised the pad abort capabilities. However, it contributed little to high dynamic pressure aborts. The full blast shield, also, contributed little to pad escapes but improved survivability of high dynamic pressure aborts. This was because the retro-rocket action would cause a "popgun" effect. This option, also, required venting. A full blast shield and TVC covered both abort areas. After analysis, it was apparent that blast protection alone was not acceptable due to the lack of a pad escape capability. A full blast shield and TVC cost and weighed too much. The best compromise was local blast protection and TVC; it had the best pad abort and adequate mode B survivability. The cost and weight addition of a TVC was not excessive - the recommendation was accepted. At any one time, management had to cope with several such problem areas.

Gen. Berg found it both the most demanding and rewarding part of a 30 year Air Force career. A tremendous amount of responsibility goes with managing such a high cost and highly important project as MOL. There are many people, at many levels of government and industry, looking over the manager's shoulder. Sometimes decisions would be reversed during the review process. Despite MOL management's strong objections, Secretary of Defense McNamara directed the use of fixed price contracts. Management's objections were based, almost solely, on the pioneering nature of MOL. With the introduction of the first technical problem requiring a change in design, the fixed price became pretty well unfixed. The key to managing such an effort is to have the best, most talented people working on the project, then providing them with the necessary delegation of authority and the responsibility to do the job. To keep track of all the various strands of the project, a control centre was established to serve as a collection point for information. It was a huge room at least 75 ft (22.8 m) on each side containing status boards that covered each part of the programme. The boards were updated every four hours. The contractors each had a mini version covering their part, so there was a constant and current flow of vital information between the programme office and each of the contractors.

Another important fact was that the office also served as the prime contractor; another unpopular directive issued from higher authority.

The Management's team's most persistant problem turned out to be in the budget area. In early 1966, funding constraints required changes in the technical approach and schedule. By the fall of 1967, this problem had reached such proportions that a major technical audit and evaluation of the development programme was required. Called Project Upgrade, it included programme deletions, elimination of certain tests, assembly requirement changes and a closely integrated use of hardware components in contractor tests. Budget-induced slippages in the launch date were the inevitable results. Yet, despite all of this, the Management team was able to keep MOL on track and fully confident of its ultimate success.

The cancellation came as a complete surprise. It is understood that the actual decision was made at a meeting between President Nixon, National Security Advisor Dr. Henry Kissinger and Budget Bureau Director Robert Mayo. Mayo had been



The Gemini spacecraft was used as the ferry vehicle in a number of space station studies in the 1960's. This Douglas concept shows a "double" station (a second Gemini is just visible at the bottom) carrying solar arrays and a large telescope.

Douglas

leading the opposition to MOL in the Executive Branch [3]. After the meeting, Mayo telephoned Defense Secretary Melvin Laird and told him of the President's decision. Laird, normally the calm gentleman, was reported to be very upset and objected strongly, but to no avail.

Missions

Because of the uncertainty of the effects of long duration space flight, mission planning was somewhat tentative. The first mission would be, by and large, limited to testing the crew's ability to cope. If there were no major medical problems, they could immediately begin flying military experiments. Should there be problems, the phase-in would be slower. No crews were organised before the cancellation (it was too early).

All 17 of the individuals selected to become MOL astronauts were test pilots with engineering backgrounds. (The Air Force did not refer to them as "astronauts", believing this term should be reserved for those who actually flew in space.) Their duties were similar to those of NASA astronauts. They were part of the engineering office and acted as checks and balances on the design work. They also participated in tests and used the Gemini simulator. There were no follow-on missions either planned or authorised beyond the two unmanned and five manned flights. MOL would have to answer those troubling basic questions before such a programme could even be considered. The MOL team, however, always assumed that a follow on would be authorised. This is the reason why 17 crewmen were selected when there were only 10 available seats. This hypothetical follow-on would most probably have begun with a programme extension. This could have been either a series of test missions or operational flights. The test missions could conduct more advanced experiments and have longer stay times (there were hundreds of people who wanted to fly experiments).

In the second option, the MOL would have flown in an open-ended series with perhaps two or three missions per year. High resolution photo-reconnaissance of selected targets would appear to be a likely operational choice since this would have provided an immediate return on development costs. The closest approximation of this option is the Big Bird reconnaissance programme which, in reality, fulfilled this role [4]. In either option, the MOL vehicle would have had only slight modifications.

An even more ambitious permanent space station could later have been developed. During the mid-1960's, the *Air Force and Space Digest* magazine published several speculative artists' concepts of such advanced MOL missions. A general theme was the orbital assembly of several MOLs, increasing the amount of equipment. Ultimately a space station could have been assembled from MOL components. This Air Force base in the sky could have undertaken world-wide real time surveillance, communications duties and satellite repair [5].

A factor which could have limited such ambitious plans was the MOL design. Unlike Skylab or Salyut, the transport spacecraft and laboratory were launched as a single unit. Each mission needed a new lab; this was because the MOL studies began in 1962-63 before much was known about rendezvous. Several NASA and industry proposals at this time also used this single unit concept. Orbital assembly, resupply and the rotation of crews would require major modifications to both the laboratory and Gemini B. Another factor is the political environment of the early 1970's. Times had changed since MOL's approval; space projects were facing much stiffer opposition than they had during the 1960's. In addition to cancelling MOL, this also led to the curtailment of Apollo, the elimination of any Skylab follow on, the cancellation of plans for a NASA space station and keep funding for the Space Shuttle at a dangerously low level. Because it would be supported by the Air Force budget, it would have had to compete with such high priority/high cost programmes as the F-15 and B-1. If MOL had progressed to the point of a permanent space station, it would have also reopened the question of civilian versus military roles in space. The closest real life example is the Salyut 6 space station programme.

The Last of MOL

As MOL was being cancelled, McDonnell Douglas Aircraft was completing a NASA design study for a space station resupply vehicle developed from Gemini and MOL technology. It was called Big G. The Gemini capsule was extended back to a 13.75 ft (4.19 m) diameter heat shield, with a hatch cut into the heat shield to allow transfer via a tunnel to a cargo module. A docking mechanism and hatch were fitted to the aft end. Attitude control, rendezvous and retro-fire were provided by a single liquid propellent system.

The crew module was designed to be re-used and glide to a land touchdown using a twin keel parawing and a skid landing gear. This was much like the system originally proposed for NASA Gemini and eliminated due to technical problems and cost. The launch vehicle was to be either a Titan IIIM or the Saturn S-IC/S-IV B. The Saturn IB was considered but was finally eliminated late in the study. Launch abort was by a large Apollo-type escape tower. There were two dimensionally identical versions: the 9 man Min-Mod Big G and the 12 man Advanced Big G which used new state-of-the-art sub-systems. The general appearance of the Big G was of a shorter, fatter MOL [6]. The study was submitted to NASA on 21 August 1969, but by this time interest had moved away from a capsule approach toward an aircraft type of vehicle, either winged or a lifting body. Such a "space shuttle" could be used for resupply as well as launching and recovering satellites. Whereas Big G used expendable boosters, a space shuttle could be designed from scratch with reuseable boosters.

The Big G quietly faded away and in doing so brought the MOL saga to a close.

Acknowledgements

The author would like to thank Brig.-Gen. Russell A. Berg, USAF, Retired, former MOL Deputy Program Director for his assistance, time and insight into the project.

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ASTRONOMICAL NEWS

By Prof. John S. Griffith*

OORT COMETARY CLOUD

In 1950, J. H. Oort noted that those long period comets which enter our planetary system seem to come from a spherical shell of material around the Sun. Further work has shown the inner edge of the Oort cloud to be between 10,000 and 20,000 AU (1 AU is the distance from Earth to Sun) from the Sun. The gravitational fields of passing stars produce perturbations which deflect a steady stream of comets into orbits bringing them into the inner Solar System. Further interactions with Jupiter and Saturn produce the final orbits.

J. C. Hills of the Jet Propulsion Laboratory (*Astronomical Journal* 86, 1730–1740, 1981) shows that the apparent abrupt inner edge of the cloud is due to observational selection. Hills shows that protocomets with smaller orbits could be ejected by the perturbations of Jupiter and Saturn into the Oort cloud position and that there is probably an inner comet cloud existing with about twice as much material as the Oort cloud.

Comet clouds are also expected to be present around other stars which have massive planets like Jupiter, and also around binary stars. The author also predicts that the peak number of comets could be as many as one per hour. Evidence for ancient comet showers should exist on the Earth. He predicts that between ten and 200 comets would hit the Earth during the 700,000 year period of a comet shower. Evidence of impact may be visible as increases in cosmic dust concentrations in ocean and lake sediments. Perhaps the extinction of the dinosaurs can be attributed to a comet bombardment (see L. W. Alvarez, W. Alvarez, F. Asaro and H. V. Michel, *Science* 208, 1095, 1980).

Lakehead University, Thunder Bay, Ontario, Canada.

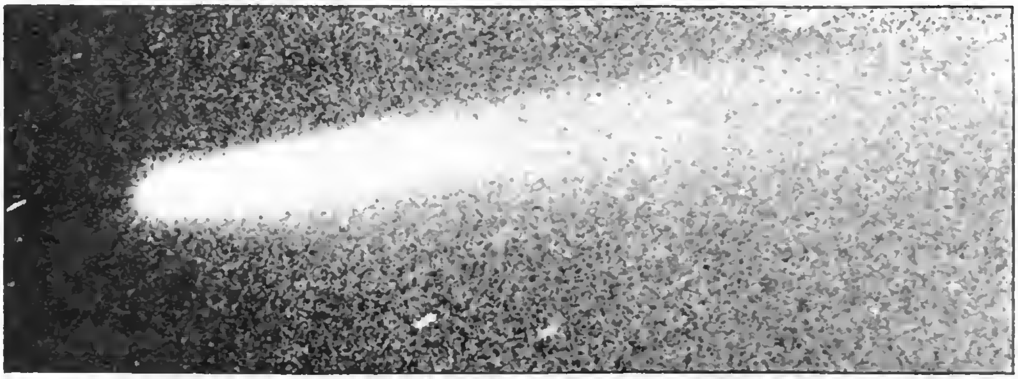
NEUTRON STAR IMPACT

In an attempt to explain an observed burst of gamma radiation from the direction of the Large Magellanic Cloud, Stirling Colgate and Albert Petschek of Los Alamos National Laboratory considered the sequence of events that would probably take place if a comet or asteroid were to directly strike a neutron star. The observations were of a short rise time, high temperature burst of hard X-ray followed by a protracted eight second pulsation.

As the core of a massive star becomes converted by fusion to iron, the high temperature breaks down the iron nuclei into smaller units. The pressure decreases and the outer layers collapse, with electrons and protons fusing into neutrons with the emission of neutrinos. The increased density of the outer layers stops the neutrinos, but the energy absorbed pushes the outer layers out, generating shock waves. A tremendous explosion leads to the disruption of the star, leaving only the core. During this explosion the core is so compressed that protons and electrons are forced together, yielding neutrons.

The mass of the high density core is between a few tenths of a solar mass to two or three solar masses, at a very high density – limited by "neutron degeneracy". Quantum mechanics tells us that neutrons resist being too close together, and the pressure generated thereby balances the gravitational force. If the mass is too large, the neutron degeneracy will be overcome, producing a black hole.

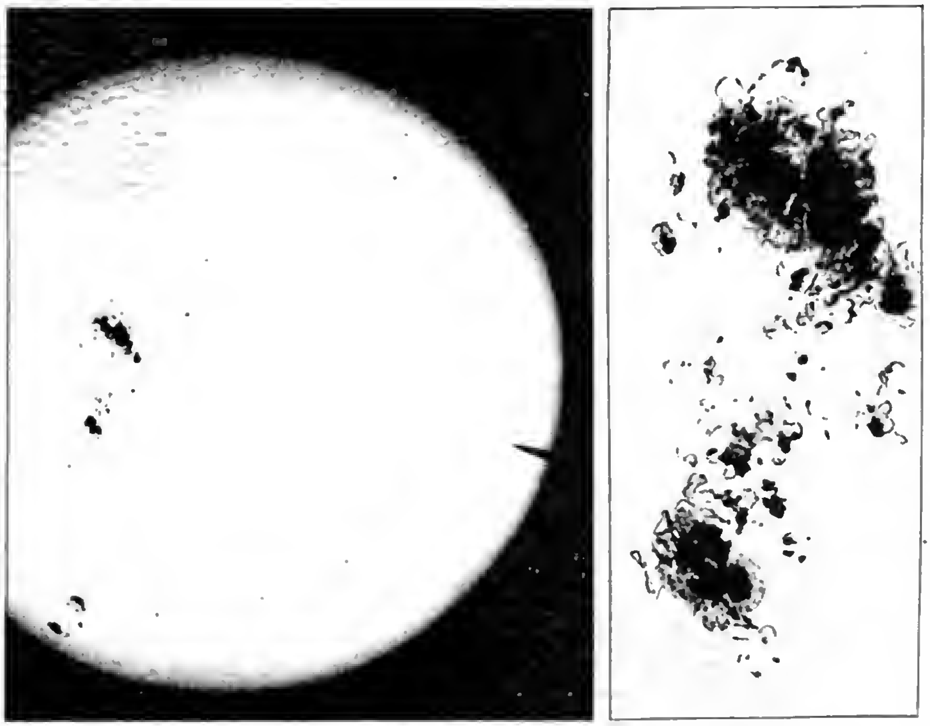
A neutron star of two solar masses would be about 20 km in diameter, with a teaspoonful of matter weighing 10^9 tons. Such a star would have a solid crystalline crust about 100 m thick, with the next few centimetres containing the photosphere, chromosphere and corona. On the crystalline crust there may be "mountains" poking a few centimetres above the atmos-



Top: Comet Kohoutek of 1974 as seen from 140 miles high by a camera aboard an Aerobee rocket. *Bottom:* Comet Ikeya-Seki of 1965.

NASA

Sunspots are regularly observed and have been known for centuries. But do other stars exhibit similar features? See the item headed "Starspots" below.



phere (the gravitational field is about 10^{11} times that of the Earth). The weak magnetic field permeating the original star is magnified by the expansion into a field much stronger than can be produced on the Earth.

Neutron stars were discussed as theoretical entities in the 1930s, but in 1967 a rapidly pulsating radio source – once every 1.3373011 seconds – was discovered. The only possible source of the pulsar signal turned out to be a rotating neutron star emitting a beam of radio waves, with the pulsation produced each time the beam was directed towards the Earth.

As an object approaches a neutron star, it becomes elongated and compressed by the intense gravational field. Interaction with the magnetic field introduces further complications, followed by an explosive blowoff. The observed long time scale of the high radiation temperature implies the existence of a "confinement stress" large compared to gravity, and the magnetic field of a neutron star is the only likely source of this stress. The high magnetic field forces the expansion of the hot matter along the flux tubes.

Such events are considered to be rare, as only the 1 per cent or so of neutron stars which remain in binary systems are likely to retain bound objects (our Solar System retains the Oort cometary cloud of primeval comet-generating material about 1 light year in radius). The paper by Colgate and Petschek is found in *Astrophysical Journal* 248, 771–782, 1981.

STARSPOTS

For a long time it has been known that there are areas of the Sun which appear darker than their surroundings. These Sunspots are cooler areas of the solar surface, although a large sunspot gives off as much light as the full Moon. Sunspots are known to be connected with the magnetic field of the Sun, varying with an 11-year cycle. Spots are formed at high latitudes and migrate towards the equator, with spots in the northern hemisphere being linked to those in the southern hemisphere.

Recently, spots on other stars have been observed indirectly. Workers at the Biruni Observatory (Iran) and Villanova University (Pennsylvania) investigated unusual variations in light coming from the variable star V711 Tan.

The astronomers working on V711 Tan were J. D. Dorren, M. J. Siah, E. F. Guinan and C. P. McCook, whose work is reported in the *Astronomical Journal* 86, pp. 572–581. They found that the changing amplitude and shape of the light curve could be explained in terms of starspots covering about 14 per cent of the stellar surfaces, with related activities such as prominences being present. The model indicates a spot cycle with the spots migrating from high to low latitudes, as on the Sun.

It is suggested that all stars similar to RS Canes Venaticorum have such systems of starspots. The first modelling of starspots was in 1952 by G. E. Kron (*Astronomical Journal* 115, p. 301) while another, more recent, reference is a paper by C. A. O. Torres and S. Ferrez Mello *Astronomy and Astrophysics* (p. 231. 1973).

THE LARGEST HOLE?

It has long been believed that, on a large enough scale, the Universe is homogeneous (ie, uniform). Inhomogeneities arise when we move down to the scale of clusters of galaxies.

Various clusters of galaxies are known. The "Local Group" contain around two dozen galaxies in a volume about 1 Mpc in diameter. Apart from our Galaxy, the Milky Way, other well known galaxies in the Local Group are Andromeda, M33 and the Large and Small Magellanic Clouds. Larger clusters include the Virgo Cluster (about 2 Mpc across and 2×10^7 pc away), the Coma and Perseus clusters. There are even Superclusters – for example the Local Group, the Virgo cluster and other smaller cluster form the "Local Supercluster" about 100 Mpc across.

The reason for the observed inhomogeneities is not yet fully understood. Four astronomers working at different institutions in the United States carried out an investigation of the scale of inhomogeneity by surveying redshifts and positions of galaxies. Robert Kirshner of the University of Michigan, Augustus Oemler of Yale and Paul Schechter of the Kitt Peak National Observatory were joined by Stephen Schectman of the Mount Wilson and Las Companas Observatories in obtain-

ing and analysing the observations. There was clear disagreement between the expected distribution of redshifts and that observed.

The discrepancy is due to a large vacant region about 2×10^6 Mpc^3 in volume (1 parsec = 3.26 light years) situated in Bootes. The authors of the paper in *Astrophysical Journal Letters*, 248, L57-L60, 1981 promise a more extensive investigation of galaxy redshifts and galaxy properties in the vicinity of the void.

QSO's and QSR's

QSO's are star-like objects whose ultraviolet images are brighter than their blue images, but they do not emit any detectable radio radiation. QSR's are similar objects that do emit radio radiation. Both quasi-stellar objects and quasi-stellar radio sources are grouped together under the heading of "quasar". Quasars appear brighter in the ultraviolet because they are receding from us at tremendous speeds, with the Doppler shift moving the lines of hydrogen towards the red. Doppler shifts of between 16 per cent and 353 per cent have been found. Remember that at these high redshifts the relativistic form of the Doppler equation gives high velocities, but still below the speed of light.

With our interpretation of Hubble's law as giving higher speeds of recession at greater distances, quasars are the farthest known (and presumably the youngest) objects in our Universe, with their light having taken billions of years to reach us.

J. B. Hutchings and D. Crampton (Canadian Dominion Astrophysical Observatory), B. Campbell (Canada-France-Hawaii Telescope Corp.), A. C. Cower (University of Victoria) and S. C. Morris (Dominion Astrophysical Observatory) have recently completed morphological studies of 29 QSO's. All have accompanying nebularity or "fuzz". QSO's appear to form a continuous progression with Seyfert galaxies, and many have structure resembling features of spiral galaxies. Some are ejecting material along their rotational axis. It appears that close encounters between galaxies temporarily fuel supermassive bodies at galactic centres.

A. C. Cower (University of Victoria) and J. S. Hutchings (Dominion Astrophysical Observatory) have apparently discovered a QSO with precessing radio jets. The quasar 4C 18.68 is a $16^m.5$ QSO of redshift $z = 0.313$. It appears to show relativistic ejection in opposing directions with a precessing double jet having a period of about 5×10^4 years, consistent with the presence of two massive interacting massive bodies in the central source. The speed of ejection is about 0.7c. Several similar structures are known, for example NCC326 (discussed by R. D. Ekers, R. Fanti, C. Lari and P. Parna in *Nature* 276, 588, 1978).

NEUTRINOS AND THE UNIVERSE

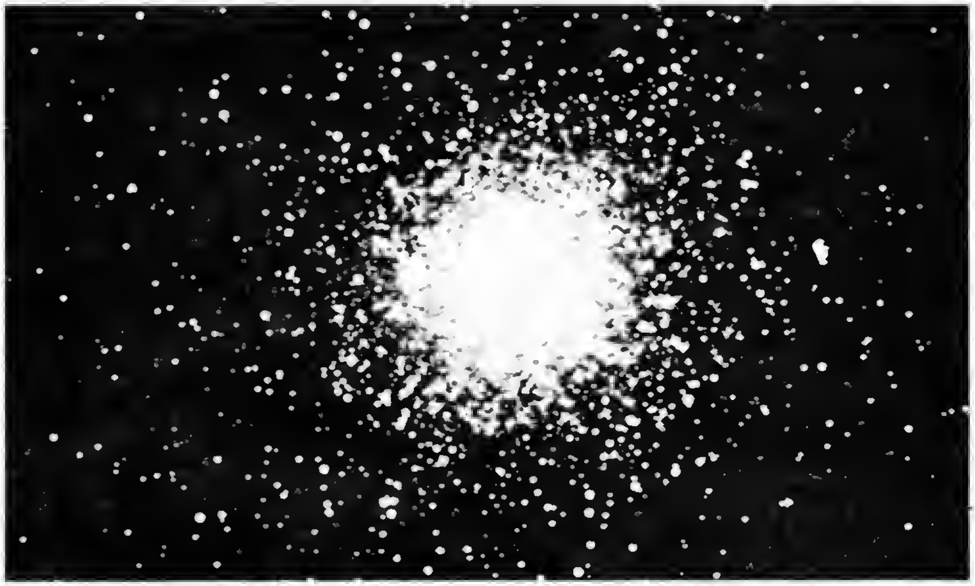
When observing the motion of different galaxies in a galactic cluster it is evident that, to maintain the cluster as an independent body over a long period, there must be sufficient mass to hold the galaxies together. For many clusters there does not seem to be enough observed mass present to maintain the cluster. The Virgo Cluster needs 50 times more mass than is observed, and the Coma Cluster seems to be missing 90 per cent of its mass.

This is the famous "missing mass" problem, though it should probably be called the "missing light" problem, as the mass inferred from gravitational effects is non-luminous. Various explanations have been put forward, from faint stars, dead pulsars, black holes, to very hot or very cool gas. A good review of the entire problem is given by S. M. Faber and J. S. Callagher in the 1979 edition of the "Annual Review of Astronomy and Astrophysics" (17, 135).

Another explanation is given by D. N. Schramm and C.

The spiral galaxy NCG 6744.

Anglo-Australian Observatory



M13, a star cluster in Hercules.
US Naval Observatory

Steigman in their paper "Relic neutrinos and the density of the Universe" (*Astrophysical Journal* 243, 1-7, 1981). They consider the possibility that the Universe is dominated by massive but light, relic neutrinos. (The neutrino is a neutral body which travels close to the speed of light. Its mass is less than 0.0001 of the mass of an electron.) Neutrinos are known to have a finite rest mass and can account for most of the mass on the scale of clusters, while contributing significantly to the mass on somewhat smaller scales.

The effect of these neutrinos on galaxy formation is also investigated. Each cubic centimetre of the Universe may contain about 100 neutrinos, so most of the matter may be in the form of neutrinos. Their presence could dilute the effects of perturbations, and, together with ordinary nucleons, the total mass could give rise to a closed or "flat" universe.

Their effects on galaxy formation are investigated by F. R. Klinkhamer and C. A. Norman in "Massive neutrinos and galaxy formation", *Astrophysical Journal Letters* 243, L1-L4.

GLOBULAR CLUSTERS

Globular clusters appear to observers with small telescopes as small hazy areas in the night sky. Larger telescopes reveal them to be many thousands of stars (tens of thousands to a million) packed together in a spherical distribution up to 100 parsecs across. RR Lyrae variables are used to determine the distances of many globular clusters surrounding our Galaxy. They are found in the galactic halo (above and below the galactic plane). There is no interstellar dust or gas associated with them, and they have low abundances of elements other than helium. Presumably they are composed of old stars, formed during the early history of our Galaxy. They provide a tool for probing the earliest epoch of star formation.

A newly discovered globular cluster system around NGC 5128 (the radio source Cen A) was investigated by J. E. Hesser, H. C. Harris and S. van den Bergh of the Herzberg Institute of Astrophysics at the Canadian Dominion Astrophysical Observatory and C. L. H. Harris of the University of Waterloo. In all, 19 clusters were identified with "metallicity" similar to that found in other globular cluster systems. The 12 new clusters resemble W Cen, the most massive and luminous cluster in our Galaxy. It is pointed out that identification of more typical globular clusters is a challenge that probably needs the Space Telescope (due to be launched by the Shuttle in 1985) to resolve.

Globular clusters in eight other galaxies beyond our Local Group are investigated by Harris and van den Bergh in a paper in the *Astronomical Journal* (86, 1627-1641, 1981). They used the new Canada-France-Hawaii Telescope on Mauna Kea for their work.

IS GRAVITY CHANGING?

The gravitational force between two bodies of masses m, M respectively, separated by a distance r is GmM/r^2 where G is the gravitational constant. If G changes with time then the orbits of m and M will be affected. Using the particular case of the orbit of the Moon around the Earth, Tom Van Flandern of the US Naval Observatory combines values from different analyses to find that G is indeed changing if we use time as measured by atomic clocks. If our units of length and time are provided by a dynamical process (ie one relying on gravity), then G is constant.

The conclusion is that macroscopic physical phenomena which are uniform with respect to a dynamical time scale are speeding up with respect to an atomic time scale units with the number of cesium transitions (used in atomic time measurement) in the dynamical time scale becoming fewer with time. The big bang occurrence in atomic processes may not have occurred in dynamical processes! The big bang and steady state theories may have to be modified and merged.

This paper is to be found in the *Astrophysical Journal* 248, 813-816, 1981.

T 42

SATELLITE DIGEST – 155

Robert D. Christy

Continued from the May issue

A monthly listing of satellite and spacecraft launches, compiled from open sources.

The heading to each launch gives the name of the satellite or craft, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes, except where marked with an asterisk, where the time is to the precise minute as announced by the launching agency.

COSMOS 1331 1982-1A, 13027

Launched: 1541, 7 Jan 1982 from Plesetsk by C-1.
Spacecraft data: Not available but may be similar to the Cosmos navigation satellites – ie a cylindrical body with domed ends, enclosed in a cylindrical solar array, with length and diameter both around 2m. The mass may be around 700 kg.
Mission: Military communications using a store/dump technique.
Orbit: 773×810 km, 100.73 min, 74.05 degrees. The orbit is co-planar with the previous launch – Cosmos 1302 (1981-84A).

COSMOS 1332 1982-2A, 13031

Launched: 1230, 12 Jan 1982 from Plesetsk by A-2.
Spacecraft data: Possibly based on the Vostok manned spacecraft with spherical re-entry module and instrument unit. Length about 5m, diameter about 2.4m and mass around 5500 kg.
Mission: Military photo-reconnaissance, recovered after 13 days.
Orbit: 210×248 km, 89.13 min, 82.32 degrees, decaying to 195×224 km, 89.74 min just before recovery.

COSMOS 1333 1982-3A, 13033

Launched: 0751, 14 Jan 1982 from Plesetsk by C-1.
Spacecraft data: Cylindrical body with domed ends, enclosed in a cylindrical solar array, with length and diameter both around 2m. The mass may be around 700 kg.
Mission: Navigation satellite replacing or backing up Cosmos 1150 (1980-3A).
Orbit: 970×1016 km, 105.02 min, 82.94 degrees.

RCA SATCOM 4 1982-4A, 13035

Launched: 0150, 16 Jan 1982 from Launch Complex 17A, Eastern Space and Missile Centre, Cape Canaveral Air Force Station by Delta 3910.
Spacecraft data: A box shaped body 1.62m×1.25m×1.25m carries spacecraft housekeeping and a communications relay package. Power is provided from an 11.2m span solar array. The spacecraft is three axis stabilised using a gyroscope with a backup jet thruster system. The mass injected into transfer orbit was 1082 kg including a Thiokol Star 30 apogee boost motor, reducing to 550 kg at the end of the vehicle's working life.
Mission: To provide commercial communications for all of the United States and to support cable television systems through 24 channels.
Orbit: Placed into geostationary transfer orbit of 635 minutes period at 27.40 degrees by the launcher, the apogee motor was fired on 19 Jan placing it into a geostationary drift orbit before final stabilisation above 83 degrees west longitude on 28 Jan.

RCA Satcom.

COSMOS 1334 1982-5A, 13036

Launched: 1131, 20 Jan 1982 from Plesetsk by A-2.
Spacecraft data: Possibly based on Vostok manned spacecraft with spherical re-entry module, instrument unit and a cylindrical, supplementary payload at the forward end. Length about 6m, diameter about 2.4m and mass around 6000 kg.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: Initially 194×289 km, 89.36 min, 72.87 degrees, manoeuvred on 21 Jan to 226×289 km, 89.69 min and maintained close to this height for the rest of the flight with a manoeuvre to counteract decay on 24 Jan.

OPS 2849 1982-6A, 13040

Launched: 1930, 21 Jan 1982 from Vandenberg AFB, probably by Titan 3B-Agena D.
Spacecraft data: Not available.
Mission: Military reconnaissance.
Orbit: Initially 141×531 km, 91.31 min, 97.32 degrees, then circularised to 560×644 km, 96.78 min.

COSMOS 1335 1982-7A, 13042

Launched: 1102, 29 Jan 1981 from Plesetsk by C-1.
Spacecraft data: Not available.
Mission: Military, possibly radar calibration.
Orbit: 479×514 km, 94.58 min, 74.05 degrees.

COSMOS 1336 1982-8A, 13045

Launched: 1130, 30 Jan 1982 from Tyuratam by A-2.
Spacecraft data: As Cosmos 1334.
Mission: Military photo-reconnaissance, recovered or re-entered after 27 days.
Orbit: Initially 169×356 km, 89.78 min, 70.34 degrees.

EKRAN 8 1982-9A, 13056

Launched: 0912, 5 Feb 1982 from Tyuratam by D-1-E+apogee motor.
Spacecraft data: A cylinder with a pair of boom mounted solar panels and a transmitting array. Length 5m, diameter 2m and mass (in geostationary orbit) around 2000 kg.
Mission: To transmit programmes of Central Television to collective receiving stations in remote areas.
Orbit: Initially a low parking orbit at 51.6 degrees inclination, then transferred to an elliptical orbit at 47 degrees inclination, followed by circularisation into geostationary drift orbit before stabilisation above 99 degrees east (Statsionar T).

COSMOS 1337 1982-10A, 13061

Launched: 0111, 11 Feb 1982 from Tyuratam by F-1.
Spacecraft data: Not available, but probably several tonnes mass.
Mission: Probably an ocean surveillance satellite carrying out electronic reconnaissance. It is working in conjunction with two satellites already in orbit, Cosmos 1286 (1981-72A) and Cosmos 1306 (1981-89A).
Orbit: Initially 428×446 km, 93.33 min, 65.05 degrees, then maintained at that height by operation of a low thrust motor to ensure the required orbital relationship with the other vehicles.

JAPAN'S GEOSTATIONARY METEOROLOGICAL SATELLITE SYSTEM

By Nicholas Steggall

Introduction

Japan began its weather satellite programme in 1977 with the launch of GMS (or Himawari, the Japanese for Sunflower). This article takes a look at the GMS satellites and their construction.

GMS-1

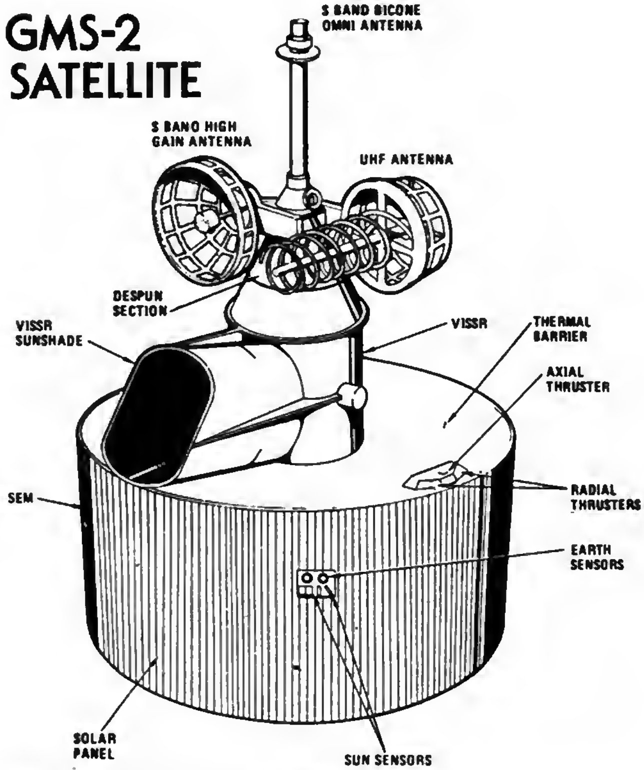
Japan launched its first Geostationary Meteorological Satellite "GMS-1" on 14 July 1977 using a NASA Delta 2914 launch vehicle from Cape Canaveral. Placed into a geostationary orbit 36,000 km above the equator and at a position of 140°E longitude (just south of Japan), it could monitor over 65 million square miles of the Earth's surface.

GMS-1 formed part of the World Weather Watch (WWW), a role which GMS-2 will continue to fill. GMS also took part in the GARP programme, the Global Atmospheric Research Programme, which was sponsored by the International Council of Scientific Unions and the World Meteorological Organization (WMO). The mission objectives are fundamentally the same for both spacecraft:

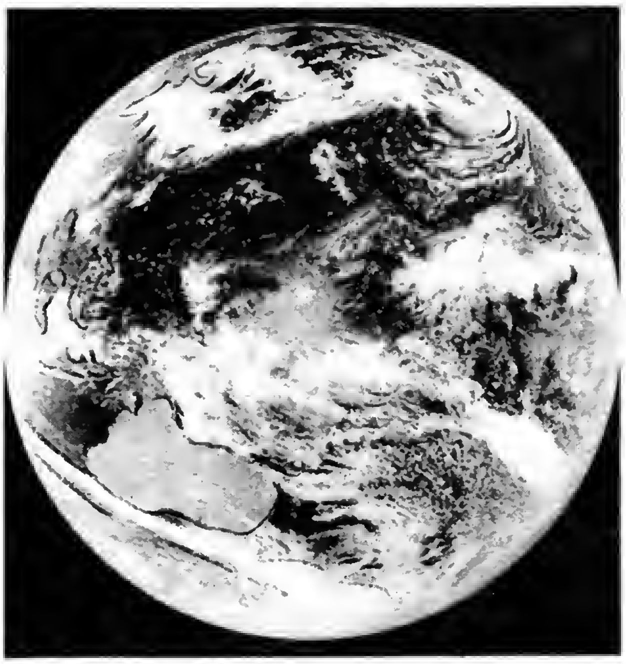
- Weather watch by the VISSR instrument.
- Collection of weather data.
- Distribution of weather data.
- Monitoring of solar particles.

GMS-2

A second generation GMS satellite was launched on 10 August 1981 from Japan's Tanegashima Space Center by the National Space Development Agency (NASDA). An N-2 launch vehicle was used to place GMS-2 into an orbit identical to that of GMS-1. Although basically of the same design as GMS-1, a number of modifications were made. Firstly, due to the difference in the launching capability between the N-2 and the Delta 2914, a reduction in weight of the spacecraft was required of about 20 kg. This was achieved by using lighter materials in the satellite's construction; for instance, GMS-1 used an Apogee Kick Motor (AKM) adapter made from magnesium alloy while the adapter for its successor was made of carbon graphic reinforced plastics. There were also fewer, but more efficient, solar cells.



Basic layout of the GMS-2 spacecraft.



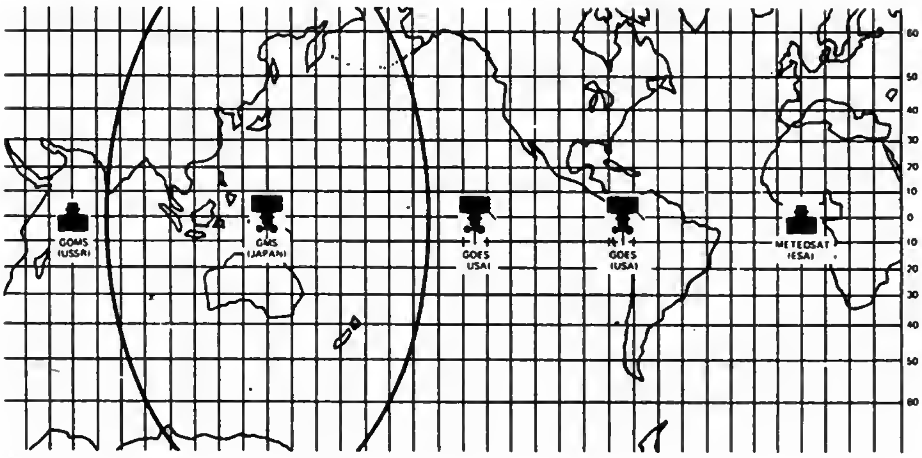
The first image from Himawari 2 (GMS-2) was received at the Meteorological Satellite Centre in Japan on 7 September 1981.
NASDA

To take into account the frequencies used by the NASA stations which supported NASDA with the tracking and control operations of GMS-2 in its transfer orbit, the frequency band was changed from UHF to S band.

As a result of the operational experience derived from GMS-1, some of the functions were upgraded, such as the improvement in the communication subsystem and the capacity increase of the electronic power subsystem. Another difference arising from GMS-1 experience was the addition of two Dynamic Balance Mechanisms (DBM's). These DBM's are used to correct deviations in the dynamic balance of the satellite in order to prevent spin axis tilt. This tilting occurred in GMS-1 a few months after launch and caused a distortion in the cloud image data. When this distortion first occurred it was adjusted successfully with the help of the ground support software system, but since September 1980 a sudden change in GMS-1's spin axis meant that the southern edge of the image data was lost.

GMS-2 Components

The overall weight, size and shape of GMS-2 had to be compatible with both the launch vehicle and also fit in with the main payload, the visible infrared spin scan radiometer (VISSR). Other obvious features are the 216 cm diameter



GMS-2 took over from GMS-1 as Japan's portion of the World Weather Watch. Likewise, the European Meteosat segment is now using its second spacecraft.

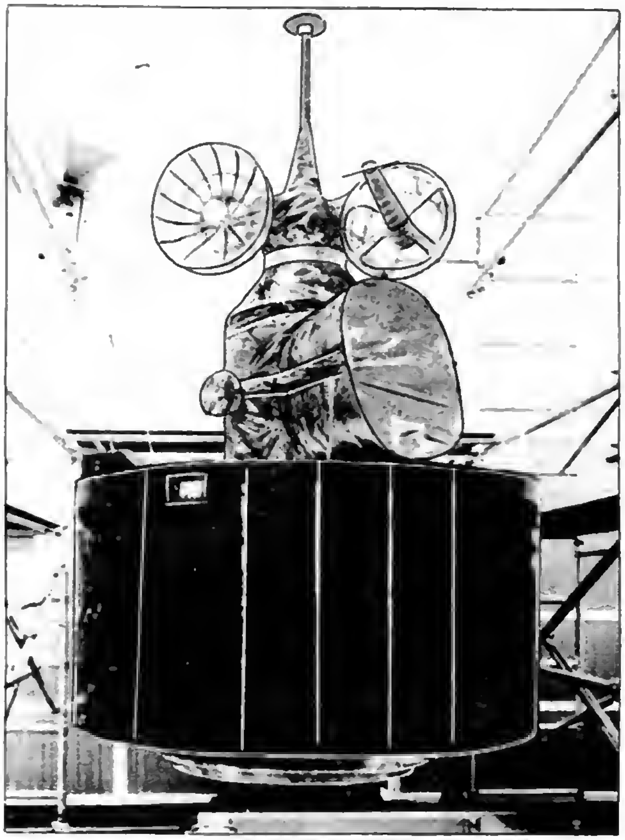
cylindrical solar array and the S band/VHF despun antenna array.

The Power Supply

Powered by the main solar array, the spacecraft is provided with 350 watts at the beginning of its life, and 264 watts at summer solstice after a period of 5 years. Charge arrays are used for high-rate battery charging during eclipse seasons and also for trickle charging for replacement of transient power on a continuous basis. A system of relay switching allows the main solar array to be used for either charging the batteries or supplying power to the main bus.

Reaction Control Subsystem

To accomplish attitude and orbit control manoeuvres, GMS has been provided with a reaction control subsystem (RCS).



Test model of GMS-2.

This consists of three tanks, with a total nominal propellant capacity of 34 kg, supplying redundant thruster groups of two radial thrusters and one axial thruster each. Each jet can provide a nominal thrust of 4.4 newtons each.

S band and UHF Antennae

The despun antenna assembly consists of three antennae, the S-band parabolic reflector, the UHF bifilar helix and the USB omnidirectional bicone.

Apogee Kick Motor

The Apogee Kick Motor (AKM) used on both GMS spacecraft was the Thiokol TE-M-616 and was used to increase velocity to circularise the transfer orbit into near-synchronous, removing 27.2° of orbital inclination. This took place on the third revolution after which the motor case and its supporting adapter were then jettisoned.

Space Environment Monitor

The Space Environment Monitor (SEM) was carried aboard both spacecraft to investigate the effect of solar activity on Earth's telecommunications systems. The SEM, developed by the Nippon Electric Company, contains five detectors for multi-mode solar particle counting: protons in the 0.8 to 100 MeV range, alpha particles in the 8 to 37 MeV range and electrons above 2 MeV.

Data from SEM is encoded into an appropriate telemetry format and is sent to a remote multiplexer. Here they are assembled with other telemetry inputs and transmitted as part of the S band or VHF telemetry signal.

VISSR

The main instrument aboard GMS is the Visible/Infrared Spin Scan Radiometer (VISSR) imaging the Earth in both visible and infrared light. The VISSR consists of a scan mirror, and primary and secondary mirrors, which collect light from the Earth's surface and focus it at the focal plane of the VISSR. Visible radiation is relayed to photomultiplier detectors through optical fibres.

Infrared radiation (10 to 12 microns) is again collected at the focal plane from where it is relayed to the infrared detectors.

Black and white images of the Earth are generated by using the spinning motion of the satellite to scan from west to east and using motor-actuated mirror stepping for scanning north to south. As about 2,500 steps are required to scan a region of 20° in elevation, a 20° window requires about 25 minutes.

Acknowledgements

The writer would like to thank E. Wilson at Hughes Aircraft Company, M. Ikeda of the International Affairs Department of NASDA, M. Komabayashi, planning division at the Japan Meteorological Agency, and D.G. King-Hele at RAE.

SOCIETY NEWS

ASTRONOMICAL STUDY COURSE

During its 50th Anniversary Year, the Society will embark on its most ambitious Study Course yet: "Update Your Astronomy". The Course, organised in collaboration with the Royal Greenwich Observatory, will provide an opportunity for members to learn of the many new and exciting developments in astronomy in recent years. Because of the number of lectures the course will extend over two sessions, with a reduced fee where Registration is made for the combined courses at the same time. Each session will probably include five lectures, a film show and a visit to a centre of astronomical interest.

Since the speakers are all active astronomers we cannot yet allocale them to specific dates. Provisional topics to be included are:

The Big Bang - The First Million Years
Updating Quasars
The New La Palma Observatory
The Distance Scale of the Universe
Observational Cosmology
Ultra-violet Astronomy
The Interstellar Medium
Advanced Imaging Techniques
Cataclysmic Variables
The Universe Through an 18 in Telescope

The dates scheduled so far for lectures are:

20 Oct 1982	23 Nov 1982
1 Dec 1982	5 Jan 1983
2 Feb 1983	3 Mar 1983
31 Mar 1983	7 Apl 1983

A visit to the Royal Greenwich Observatory, Herstmonceaux will take place on 14 April 1983. Participants will need to make their own travel arrangements but fuller details will be circulated nearer the date.

Registration forms are available from the Executive Secretary. Please enclose a stamped addressed envelope. The fee for each session is £6; for the whole course £10.

SWELLING THE RANKS

The latest addition to our ranks is Alan Farmer, recently returned from the wastes of Arctic Sweden. Alan joined the Society while he was at Cambridge in 1970. That same year he had a summer job with the then Rolls-Royce Rocket Engine Division and remembers with some pride how they allowed him, as a 21st birthday present, to occupy the 50 yard bunker as they test-fired one of the RZ-2 motors for the Europa launcher.

Alan has been working in some form or another with the Society since 1971 when, with his newly-completed degree, he came to do the Diploma in Space Science at University College London, and augmented his grant by odd-jobbing at the Bessborough Gardens offices. Rumour has it that his main attraction was not his handsome, craggy features, his literary talents, soaring intellect or even the speed at which he could stuff BIS bumf into envelopes, but rather his possession of a ramshackle bicycle, which made him the only one mobile. Sent off wobbling precariously on numerous errands into thundering traffic, his return was often greeted with some surprise.

Following the Diploma, Alan worked for BAC (now part of British Aerospace) for a year, writing for *Spaceflight* while he was there, and then came back to do research at UCL - and work as dogsbody at the BIS. His interest continued through his jobs as programmer and programming manager with computer time-sharing bureaus, but when he moved to Sweden for a 2½ year stint with EISCAT, the European Incoherent Scatter Radar Scientific Association (see November 1981 *Spaceflight*), the trip in for the odd evening or two became a little too much.

Alan Farmer, who recently joined us on his return from Sweden.

Now he's back, as Assistant Editor on *Spaceflight*, and Editor of *Space Education*. The other staff have been horrified to discover he has bought a new bicycle, although the winter dirt has at last begun to turn it into a reasonable facsimile of the one they are more used to seeing.

PLEASE PAY BY DIRECT DEBIT

To speed its accounting procedures, which already involve our staff in substantial work spread over many months, the Society's Council has decided that every member with a UK Bank Account now be invited to remit via the Direct Debit System.

This involves the completion of a very simple form which then has to be sent to the Member's Bank.

We hope to transfer all 800 who currently pay by Bankers Order to the new method. Additionally, we have to increase the number to 1,000 to make the scheme viable so we extend an invitation to every member with a UK Bank Account to complete the simple form needed in order to get this scheme off to a flying start.

The form grants permission to the Bank to remit the appropriate sum on January 1st each year. Members may select, beforehand, the amount which they wish to pay, including whichever of the Society's three publications they wish to select and include a regular donation if they wish.

The amount charged by the Society will represent no more than the Member has already agreed to pay.

From then on the Society will tackle the whole chore of collecting, recording and otherwise dealing with subscriptions. Members may safely ignore the printed reminder notices which are set out each year and, since the authority which they grant allows for changes in the subscription rates in future years, they have no need to take further action on account of these.

Members may cancel their Direct Debit arrangements at any time. Any sums paid in error can swiftly be recovered immediately afterwards.

All in all, this is a good deal both for Members and for the Society.

The only requirement is to obtain a copy of the simple form, complete it and send it to one's Bank! Forms are now available from the Executive Secretary on request.

N.B. Bankers Order arrangements will be automatically cancelled on completion of a Direct Debit Authorisation.

SOCIETY MEETINGS

SOLAR ASTRONOMY

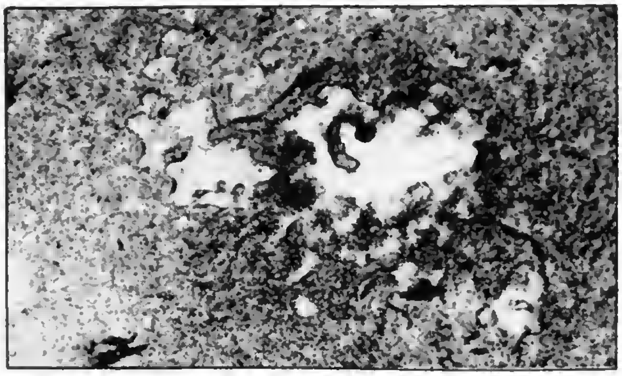
The spectacular recent observations of Jupiter and Saturn by the two Voyager probes have tended to place other Solar System research in the shade. The Society was therefore fortunate in having Dr. C. O. Cough of the University of Cambridge to talk on "Recent Advances in our Knowledge of the Sun" in its Conference Room on 27 January.

Before getting down to the "nitty-gritty" of his own work he gave a lucid summary of previous research into the Sun's shape (is it round or slightly flattened at the poles?), a topic of vital interest to astronomy and relativistic physics.

Dr. Cough has recently been analysing the "residuals" in measurements of the Sun's shape by Hill. The residuals are normally dismissed as experimental error or as uncertainties arising from viewing the solar disc through the thickness of the Earth's atmosphere. Hill was trying to improve on work done by Dicke, a relativistic physicist with whom he had previously worked. Dicke's interest in the Sun's shape came about because his own "field theory", in contention with Einstein's, required the Sun to be oblate to account for the "relativistic" precessing of the orbit of Mercury. This 43 arcsecond/century motion is normally quoted as one of the "proofs" of Einstein's Theory of Ceneral Relativity.

Dr. Cough wants to see if he can explain the differences between the two sets of measurements in terms of oscillations of the Sun's surface. By using statistics it now seems that information may be extractable on the Sun's oscillational modes and hence its internal structure. The work is still in its early stages, but the initial results look encouraging.

Questions from members took up various aspects of the work, including the use of space probes in solar studies. Since one of the main problems with ground-based work is the quality of "seeing", a space platform is an attractive extension of the observational method. Here it was a question of the available funds, competition from other projects, and the trade-offs between alternative methods. Sending space probes in towards the Sun is expensive because of the launcher energies involved, but some Earth-orbiting solar observation satellite projects are currently under study.



A solar flare observed in 1959.

SMALL UNIVERSE

The Society's Conference Room was filled almost to capacity on 16 September 1981 to hear Mat Irving tell us about designing the special effects for films and TV programmes on space topics. We could hardly see Mat behind a wall of space models. There were two Shuttles (one with a Spacelab), bits and pieces of Daedalus, a Skylab, Apollo, Soyuz, Voyager, the HEAO (Einstein) observatory, a Lunar Dozer and Martian Rover, an Ariane rocket, and even futuristic space laser and particle beam weapons. Fictional programmes were represented by a Privateer and a small pursuit ship from "Blake's Seven". Some of the models were Mat's own, while others were borrowed from the BBC for the talk.

Mat has been involved in many TV programmes, from "Horizon", through various Open University and schools programmes, "Sky at Night" and "Tomorrow's World", to James Burke's coverage of the Apollo-Soyuz flight. Less serious programmes have included "Hitchhiker's Cuide", "Dr. Who", "Blake's Seven", and even an episode of "The Coodies". Mat's work is not restricted just to space vehicles: he has made a working model of an Intelsat orbiting the globe for a two-part programme entitled "Satellite Case Studies". Another OU programme. "Astronomy before Copernicus", required the construction of an attractive model of an Earth-centred universe for an Arts course. At present he is working on a model of Saturn and all 12 of its moons outside the E ring.

We learnt many of the tricks of the trade. In "Blake's Seven" a model of the Liberator was placed in front of a highly reflective screen. A 3-by-3 slide front-projected on the screen gave the impression that the Liberator was in orbit about Planet X. Changing the slide to one of Planet Y was "quicker than a hyperspace jump".

We discovered that the Martian surface can be simulated by the contents of tins of a well-known brand of cocoa, backlit with red lamps, Moondust could be modelled by sawdust or, better still, by white self-raising flour with a small amount of black poster paint mixed in. He showed us a clip of film of the radio-controlled Lunar Dozer ploughing through this inedible Moondust, with expanded polystyrene hills in the background. Models were usually filmed at high speed, and then slowed down to give a realistic impression of inertia.

Models are made of anything and everything, mostly plastic. They might take from two to three days to make (eg, Voyager), and might have been rebuilt many times.

Mat admits to being a terrible scrounger. A key feature of the Vogon ship in "Blake's Seven" was a strip of electrical connectors. Galaxies are saucer-shaped fibreglass mouldings, internally lit by quartz-iodine lamps and with fibreglass threads teased out. Groups of galaxies are suspended in space on the ends of black-painted baulks of 2-by-1 timber.

Plastic kits are useful for the detailed "dressing" of models. A contractor supplies cylindrical tubing and hemispheres in a variety of standard sizes. Doubly curved parts, such as the Shuttle's External Tank nose and engine bells, were moulded. In his search for realistic thruster quads for an Apollo model, Mat raided the BBC stores for ballpen tops, much to the storeman's dismay.

Audiences have become much more demanding. Mat showed us a "nostalgic" photo of his first scene of Apollo in space against a background of stars set in a blue sky. The exhaust of rocket motors is very difficult to do, because "Thunderbirds"-style flames are just too unsophisticated nowadays. Mat's technique is to use a can of freon with four quartz-iodine lights inside the rocket model. He is able to simulate the exhaust for about 15 seconds, but timing is critical. If the freon can ruptures too early then everything freezes solid. If it's too late then the model melts in the heat of the lamps. We saw a slide sequence of one of these dramatic disasters. Laser light now offers a wide range of abstract effects, especially when combined with smoke.

Such sophistication is costly of course. Mat told us about a forthcoming programme based on the Tenerife collision of two Jumbo jets, saying: "The producer had to use models, obviously, because it was cheaper than the real thing (but not much!)"

T. J. C.

BOOK REVIEWS

The Coattails of God
Robert M. Powers, Warner Books, 288pp, 1981, $15.95.

The central idea of this book is that Man will go to the stars and that, at least initially, he will do so in vast generation ships such as those proposed by Bernal.

The text touches on many subjects familiar to readers of the BIS magazines, e.g. the development of rocketry and its current limitations, CETI, the possibilities of finding habitable planets, the development of interstellar vehicles, and an outline "future history" that might lead to construction of such a ship. There is not a lot that would be new to assiduous readers of *JBIS* or *Spaceflight* but, as a convenient summary of the main features of the interstellar debate, this is a start, though it leaves two fundamental "why's" unanswered. Why will Mankind go to the stars? The fact that humans have built faster and faster vehicles over the past two hundred years is not really a sufficient answer. Secondly, why should it be done in the way described? There is an attempt to answer that but it is by no means complete.

The foreword does a good job in putting such an endeavour into the context of other great engineering feats but then doesn't provide a really convincing reason for pushing though such a mammoth project in some conceivable future social context.

The book's title comes from a quote from Ray Bradbury, which explains much in the author's approach. He has provided a popular account, full of the excitement of adventure, without going too deeply into technicalities. His text will appeal to those who want light, but inspiring, reading. Unfortunately, it doesn't bear up to an examination in depth. Errors of detail spoil it for more thorough reading. For example, Gagarin's (presumably orbital) velocity is quoted in Mach Number, the Saturn 5 *thrust* is quoted in horsepower, the impression is given that the first satellite was launched by a liquid hydrogen/liquid oxygen vehicle, among others. Occasionally noteworthy facts are produced, but this is counterbalanced, for example, by the footnote on p. 43 which is either out of order in the text or the result of incredibly fuzzy thinking.

This is an optimistic book revelling in the wonders of science and technology, somewhat in the style of *OMNI*. Sometimes one wonders if such optimism should be tempered by more realism. The caption to one picture reads: "It is difficult to predict what form a starship society might assume; it will probably involve freedom and individuality of expression". We would like to think so, but nearby in his text the author describes psychological problems uncovered during Spacelab simulations, yet doesn't weave those in a way to show that "freedom" provides the obvious answer to them.

The BIS gets its fair share of mention, both from its early days (A. C. Clarke gets credited with the invention of the mass driver) and for its Daedalus work. The latter gets a fairly long write-up, with the Daedalus probe seen as the unmanned precursor to the colonising ship.

The book ends with a very useful set of references.

Space Activities in the Eighties
European Space Agency, ESA SP-1012, 1080 pp. (3 vols), 1981, Fr.300.

These three volumes present what must be one of the most comprehensive overviews of space programmes in Europe and the rest of the World.

The first volume concentrates on a general, but extensive, survey of projects underway in 1980 including those in the USA, Japan, India, China and the USSR. The activities of the European nations involved in ESA are broken down in detail.

The second volume is even more detailed, presenting a directory of European companies and their involvement with space projects. Volume 3 completes the picture with a directory of non-European company involvement (mainly, of course, American).

The Surface of Mars
By M. H. Carr, Yale University Press, 232pp, 1982, £31.50.

The 1970's saw an explosive growth in our knowledge of Mars. The decade began with the Mariner 9 orbiter, which sent back pictures of huge volcanoes, canyons, flood features, and lava plains, all evidence that the planet had a complex and varied geologic history. In 1976 two Viking spacecraft were put in orbit around Mars and another two made soft landings on its surface. These vehicles returned a continuous flow of data to Earth for the rest of the decade.

The author was leader of the Viking Orbiter Imaging Team, responsible for the development and use of cameras on the Viking spacecraft and for coordinating interpretation of the data acquired. In this book he summarizes our present perception of Mars – what the surface is like and how it evolved to its present form – the first such work to integrate all the Viking results.

His study begins with several introductory chapters which compare Mars with other bodies in the Solar System, outlines the history of Martian observations and discusses the general features of the planet. He then offers details and explanations for its unique surface geology, craters, the nature and distribution of plains, volcanoes, etc., concluding with an account for the search of life on Mars, a description of its two moons, Phobos and Deimos, and a synthesised geologic history of the planet.

This is really a most excellent work on Martian geology, likely to stand the test of time for many years to come.

Extragalactic Adventure, Our Strange Universe
J. Heidmann, Cambridge University Press, 174pp, 1982, £12.50 (£4.95 paperback).

Beyond the Milky Way lies the immense Universe of a billion galaxies, in singles, groups and clusters extending right out to the cosmological horizon, and including radio galaxies and quasars emitting enormous energy.

How does one explain the red-shift? Is space so strongly curved that, by going "straight ahead" we will come up behind ourselves! Is it likely that the apparent expansion of the Universe will continue forever, thus leaving us more and more isolated, or will the newly-discovered black holes enable us to communicate with Universes existing parallel with our own? Was our fate really all decided in the first quarter of an hour after the Big Bang?

These are some of the enormously interesting points which the author attempts to answer, without using equations or complicated formulae. He has prepared a short but readable book which will leave readers thirsting for more.

A Complete Manual of Amateur Astronomy
P. Clay Sherrod, Prentice/Hall, 319pp, 1982, £8.20 (Paperback).

This is an excellent book for the amateur who, having acquired his first telescope, wants to look around to see what to do next. He can do no better than get this handy guide. It has been prepared by an amateur astronomer and synthesised over a period of years from an enormous initial accumulation of notes.

The first chapters are concerned with telescope selection, set up and maintenance, followed by sections on meteors, comets, the Sun and Moon and then the various planets in turn, ending with studies of variable stars and a section on astronomical photography.

This bare description does less than justice to a book which is essentially practical in character and designed to get straight to the "nuts and bolts" of amateur observing. It is filled with practical advice and examples, adequately referenced and with plenty of guidance to organisations catering for particular interests.

Planetary Encounters
R. M. Powers, Sidgwick & Jackson Ltd. 368pp, 1982, £8.50.

This volume covers the history of automated space probes up to Mariner, Pioneer, Voyager and Viking, together with what information thus gleaned from their observations of our planetary neighbours.

The author begins with the pre-Christian era, tracing the development of ideas, and proceeds through the history of rockets to an assessment of present-day capabilities. Each of the planets is introduced in turn, chapter by chapter, with missions to the outer planets now in the planning stages fully described and possibilities for exploring and mapping the entire Solar System analysed.

Some of the above notes are not Reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

CORRESPONDENCE

Voskhod and Soyuz

Sir, Since the publication of James Oberg's excellent article "Soyuz 1 Ten Years After: New Conclusions" (*Spaceflight*, May 1977, pp. 183–189) there have been numerous letters of correspondence. Amid all the discussions of the mission, one point seems to have been missed. The concept of two Soviet manned spacecraft docking and the crew making an EVA transfer had been around for at least five years before Vladimir Komarov made his fatal and still controversial mission. The earliest reference I have seen is the 24 August 1962 *Life Magazine* (after the Vostok 3 and 4 flights). It shows an artist's concept of two bullet-shaped Vostoks docked tail to tail. The ejection seats and hatch covers have been extended and a cosmonaut is transfering. The text said that this manoeuvre was believed to be the next step in the Soviet space programme [1].

Rendezvous and transfer would next appear after the flight of Voskhod 2. *Aviation Week & Space Technology* alleged that the Voskhod 3 countdown was halted shortly before launch, some 18 to 19 hours after the Voskhod 2 launch. A rendezvous and transfer was expected by US observers and was rumoured in Moscow [2]. As NASA was preparing the Gemini 6 mission the rumours again appeared, *Aviation Week* carried an article predicting that a multi-manned, 15 day mission would be the next Soviet flight. Three mission profiles were mentioned. A dual launching of manned Voskhod spacecraft with rendezvous and docking was the primary goal, with a long duration flight as the secondary one. The second profile was the launching of a manned and an unmanned Voskhod. They would rendezvous and one or more cosmonauts transfer to the unmanned spacecraft. The third was a manned circumlunar flight. The article continued that Soviet scientists considered the transfer of cosmonauts from one spacecraft to another to be a key step toward the construction of a space station [3]. A few months later, in early 1966, the Czech technical journal *Veda a Technika Mladezi* said that in 1967 two manned Voskhods would be launched for a two week mission that would include rendezvous and docking [4]. (This, however, could have used the *Aviation Week* article as a source rather than being independent confirmation.) After this, such reports were tied to the Soyuz 1 flight.

CURTIS L. PEEBLES
California

REFERENCES

1. *Life Magazine*, 24 Aug 1962.
2. *Aviation Week & Space Technology*, 29 Mar 1965.
3. AWST, 1 Nov 1965.
4. AWST, 14 Mar 1966.

Satellite Earth Station

Sir, The item on the Eik satellite Earth station in Norway, which appears on p. 272 of the last October's *Spaceflight*, needs correcting. This station is indeed being equipped for operation with Marisat, but the accompanying photograph shows the original 13 m antenna, which since its inauguration on 7 July 1976 has been providing vital communications with Norway's offshore oil installations using a 4/6 GHz Intelsat-IV satellite.

I believe that the new Marisat antenna is located on the hillside at the other end of the station building from the original antenna (so it would appear behind the station as shown in the October *Spaceflight*).

In fact, the station shown is interesting in its own right. The Norwegian Domestic Satellite System, of which Eik is the Main Station, was the first domestic satellite communications system operating in Western Europe, and I believe it is only the second in the world to use a leased Intelsat transponder (Algeria was first). It was also the first satellite communications system to provide the primary, permanent means of communications with offshore oil production facilities. The UK, in contrast, uses troposcatter techniques, with satellites well in the future.

The offshore outstations, with their 8 m antennae, are the smallest Earth stations regularly working an Intelsat satellite for routine communications service. (The one at Ekofisk is also, to my knowledge, the first and maybe only one ever to operate successfully mounted 60 m above the sea on a wall bracket, peering out from under a helicopter landing deck).

One of the other outstations is yet another kind of record-breaker. Having a larger antenna than the others, it serves Longyearby in Svalbard (Spitzbergen), and at over 78 degrees north latitude it is probably the furthest Earth station from the equator to be served by a Clarke-orbit satellite. The operating elevation at Svalbard is only a little over 1 degree, which illustrates why the Soviet Union, with its large northern territories, is keeping its 12-hour orbit Molniya system operating despite the introduction of a Clarke-orbit system.

Incidentally, the photograph of Eik which you published contains a warning for all those admirable sleuths who expend so much effort extracting vast amounts of data on the Soviet space programme from scanty photographic evidence. In the case of any Earth station it is possible to determine, say, its location from a photograph, provided you know where the satellite is. However, I am pretty sure that your photograph was taken while the antenna was pointing at a test beacon set up on a nearby mountain. This would totally mislead our sleuth, especially as the mountain was only a few degrees away from the Clarke orbit, resulting in a very plausible-looking pointing angle!

M. E. POOLE
New Zealand

The Editor is always interested in receiving items of correspondence, notes, comments, or reviews for possible publication. Items submitted must be kept brief, owing to the limitations of space in our magazine. The Editor reserves the right to shorten or otherwise adapt material to fit, for this reason.

SNIPPETS

Meetings
Sir, I am delighted to see such a variety of interesting meetings and lectures advertised for this year. I am particularly eager to attend those on Halley's Comet (10 February) and the Solar System (7 April).

R. C. SHALLCROSS
Surrey

The Best I Can Do!
Sir, Enclosed is my subscription to *Spaceflight* and £2 for your Stage 2 Development Appeal. I would gladly give more but with being on a student grant I am unable to. I look forward to receiving *Spaceflight* every month – value for money indeed!

K. J. DASH
London

If Only
Sir, I wish that I lived in London where the BIS keeps up this tradition of exciting and interesting meetings.

Prof. HARRY O. RUPPE
Munich, W.Germany

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G. V. Groves.

Assistant Editors:
L. J. Carter
A. D. Farmer

Managing Editor:
A. Wilson

CONTENTS

290 **Probing the Giant Planet**

295 **The Maiden Voyage of "Columbia": Part 2**
John Pfannerstill

300 **Space Communications**

302 **The Original Voyager**
Curtis Peebles

305 **News from the Cape**
Gordon L. Harris

310 **Preliminary Results from STS-3**
LeRoy E. Day

317 **Space Report**

327 **Satellite Digest – 156**
Robert D. Christy

328 **Society News**

330 **37th Annual General Meeting**

332 **Report of the Council**

334 **Correspondence**

COVER

Space Shuttle Orbiter *Columbia* hangs from a sling above the floor of the Vehicle Assembly Building at the Kennedy Space Center, prior to its third orbital mission.
NASA

MILESTONES

March 1982

16 ESA announces that the first operational launch of Ariane, L5, which was scheduled to place two spacecraft, Marecs-B and Sirio-2, in orbit on 23 April, will need to be delayed by at least two months. This postponement is due to an investigation required because of anomalies that recently occurred on Marecs-1, which was successfully launched on 20 December 1981. The Marecs-1 telemetry and command systems have been affected by electrostatic discharge caused by increased solar activity experienced since early February. Changes in the flight control procedures have been introduced with a view to protecting operations in future. At present, the satellite is operating satisfactorily. Marecs-B may require modification to make it insensitive to electrostatic phenomena.

18 Rain-soaked runways at Edwards Air Force Base in California prompt a decision to land the third Shuttle flight at Northrop Strip, a 35,000 ft gypsum-surfaced runway at White Sands Missile Range in New Mexico. Two trains, one of 22 wagonloads, the other of 15, transfer landing equipment and vehicles 800 miles, while 100 Kennedy Space Center employees fly from Edwards to White Sands and 400 more are air-lifted from Florida to the new site. It is estimated that the change of landing site will double the processing time to 10 days.

22 It is reported that NASA is considering the possibility of moving the ISEE-3 satellite, currently in a "halo" orbit about one of the Earth's libration points, for a September 1985 intercept of Comet Giacobini-Zinner. Although the satellite carries no cameras it could provide valuable cometary data and pre-empt the European, Soviet and Japanese Halley probes.

22 Launch of the third Space Shuttle mission, carrying astronauts Lousma and Fullerton, occurs at 4 p.m. GMT. Auxiliary Power Unit 3 has to be shut down because of high temperatures; main engine cut-off comes at 8 m 34 s. The first OMS burn of 87 seconds establishes a 53×150 mile orbit, the second slots *Columbia* into a 150 mile circular orbit. Commander Lousma is affected by sickness, a problem he had during his Skylab flight in 1973.

23 The Shuttle astronauts notice that tiles are missing from *Columbia's* nose, and views from the Remote Manipulator show others missing from underneath and from the body flap. Pieces of tiles found on the launch pad indicate they were dislodged by ice falling from the External Tank during launch.

30 Shuttle Orbiter *Columbia* lands at the back-up Northrup Strip landing site in New Mexico, after a one day delay because of high winds.

April 1982

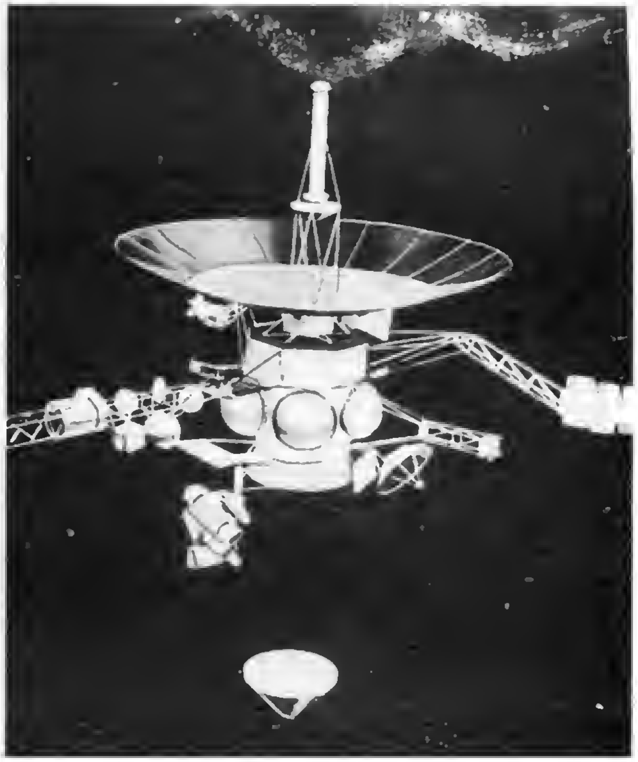
6 NASA announces that it has awarded contracts for test mirrors for its advanced X-ray astronomical satellite, expected to be launched at the end of this decade.

8 Working around the clock when desert winds permitted 500 Kennedy Space Center government and contractor personnel loaded *Columbia* onto NASA's converted 747 which takes off from Northrup Strip at White Sands Missile Range at 9 a.m. EST. The jet touches down en route to KSC at Barksdale Air Force Base in Louisiana. It is the shortest stay time at a landing site of the three developmental flights. Striving to reduce turnaround, Launch Director George Page hopes to launch the Shuttle on its last test mission on 27 June.

10 The Indian communications/meteorological satellite Insat 1A is launched by Delta 3910/PAM from the Kennedy Space Center. The satellite is designed to provide domestic and direct broadcasting services but initial indications are that the main antenna has failed to deploy properly.

PROBING THE GIANT PLANET

The Galileo mission to Jupiter, beginning in 1985, will be America's only planetary probe project of this decade. J. P. Casani of the Jet Propulsion Laboratory in California, presented a paper – "Galileo: Mission to Jupiter" – at the 32nd IAF Congress in Rome last September describing the mission. Since then, the Centaur high energy upper stage has been dropped from the planning and a new mission profile is being developed using the IUS solid propellant upper stage. BIS Fellow Dr. John Davies has kindly produced a condensed version of the original paper incorporating updated material supplied by JPL.



The Galileo spacecraft, with the probe below. *MBB*

Introduction

In mid-1985 NASA will launch its only outer planets mission of this decade, the Galileo mission to Jupiter. The two-component spacecraft, consisting of a Jupiter orbiter and an atmospheric entry probe, is designed to expand our understanding of the Jovian system gained from the Voyager project. Galileo should allow scientists to determine the chemical composition and physical state of Jupiter's atmosphere and satellites and to characterise the planet's magnetic and charged particle environment.

The quality of Galileo's scientific investigations will be enhanced by four major advances over previous missions: extended observations during the two year orbiter mission, closer flybys of the major satellites, direct sampling of Jupiter's atmosphere, and the utilization of advanced instrumentation.

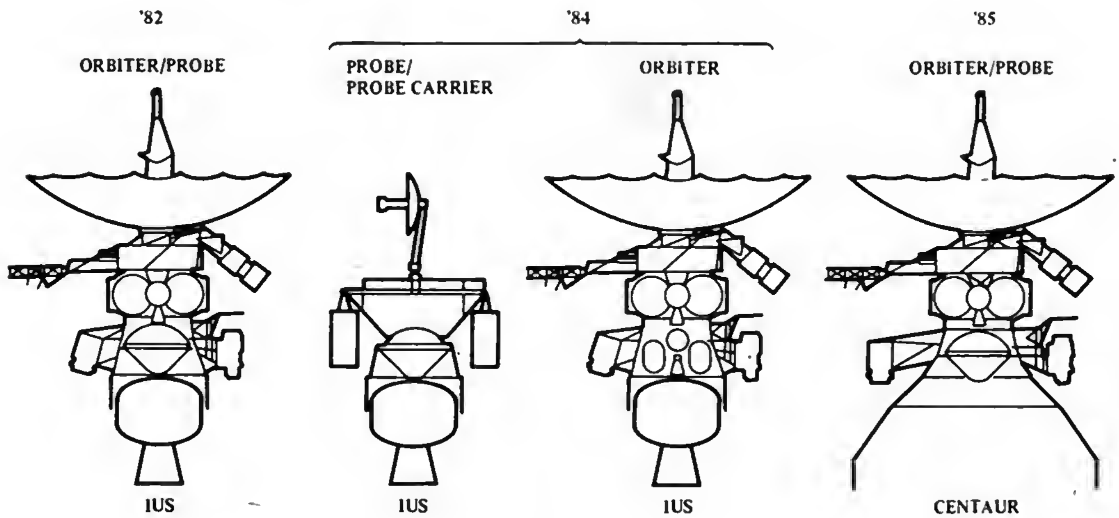
History

At its inception in 1977 Galileo was scheduled to be launched in 1982 by a Space Shuttle plus a 3 stage planetary version of the Inertial Upper Stage. The trajectory would have included a close (275 km) flyby of Mars to gain heliocentric energy, thus reducing the required launch energy.

Unfortunately, development problems with the Shuttle necessitated delaying the mission to 1984, and the resulting poorer planetary alignment required additional propulsive capability during the Mars flyby. This increased the spacecraft mass and forced the planners to divide the mission into two parts, launching Orbiter and Probe separately about 1 month apart. Furthermore, this proposal required the development of a Probe Carrier spacecraft to deliver the probe to Jupiter and to relay its data to Earth.

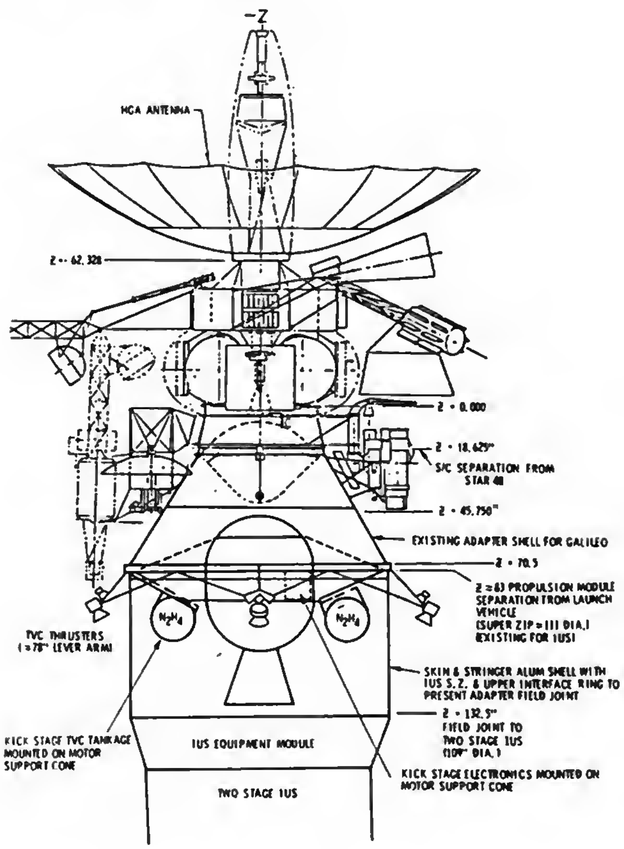
In January 1981, with continuing problems in the development of the three stage IUS, NASA decided to replace the IUS with a modified Centaur upper stage and move the Galileo launch to 1985. The higher performance of the Centaur stage allowed the Orbiter and Probe to once again be combined in a single launch. In addition, a direct trajectory was again possible, dispensing with a Mars flyby.

Later in 1981 the budgetary policy of the Reagan administration threatened the entire project with cancellation but after the congressional pressure the mission was eventually reinstated in NASA's FY 1983 budget. Unfortunately, the Office of Management and Budget's position that development of the Centaur stage should be terminated remained unaltered.



Evolution of Galileo. It will now use a 2-stage IUS plus kick stage.

JPL



Unless DoD pressure forces a revision of this policy another replanning of the mission will be forced on NASA. A modified form of the mission is described in a later section.

Table 1. Orbiter Science Investigations.

Instrument	Objectives
Solid State Imaging (SSI)	Image Jupiter and its satellites for studies of atmospheric dynamics and physical geology.
Near Infrared Mapping Spectrometer (NIMS)	Study mineralogy of satellite surfaces, as well as morphology and structure of Jovian clouds.
Photopolarimeter Radiometer (PPR)	Study photometric and thermal properties of satellite surfaces as well as cloud and haze properties in Jovian atmosphere.
Ultraviolet Spectrometer (UVS)	Study composition and structure of high neutral atmospheres of Jupiter and Galilean satellites.
Magnetometer (MAG)	Study magnetic field of Jupiter and search for magnetic fields associated with the satellites.
Plasma (PLS)	Study Jovian plasma.
Plasma Wave (PWS)	Study time-varying electric and magnetic waves in the Jovian plasma.
Energetic Particles Detector (EPD)	Measure detailed energy and angular distribution of protons, electrons, and ions.
Dust Detector (DDS)	Study physical and dynamical properties of small dust particles in the Jovian environment.
Celestial Mechanics	Study gravity fields of Jupiter and its satellites, as well as the space environment.
Radio Propagation	Study structure of atmospheres of Jupiter and satellites by use of radio signals from Orbiter and Probe.

Spacecraft Description

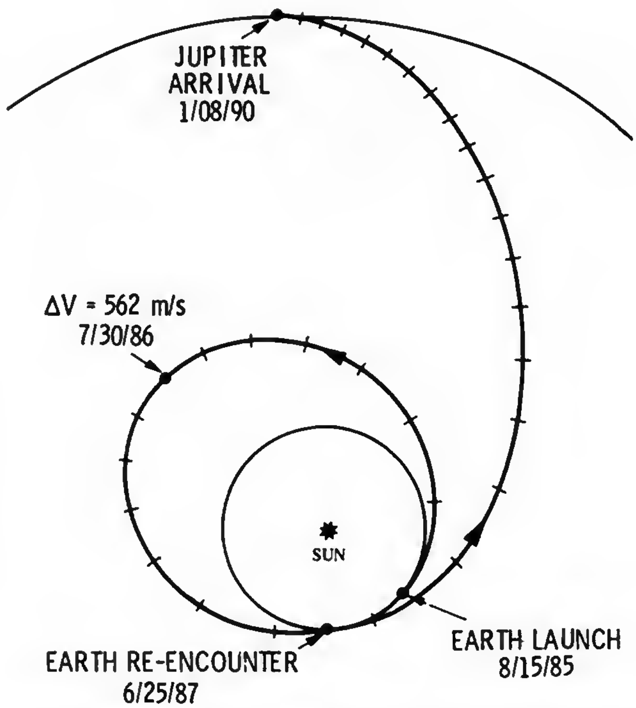
The Galileo Orbiter is a dual-spin spacecraft. Part of the craft will be three-axis stabilised to provide a steady base for those instruments which must be accurately pointed. The main body of the Orbiter will spin at 3 rpm to provide stability and to allow the fields and particles instruments to scan the sky.

The spun section contains both the high and low gain antennae, the retropropulsive module (RPM), the Radio Isotopic Thermoelectric Generators, most of the electronics, command and data equipment and the fields and particle experiments.

Galileo will use a 4.8 metre diameter high gain antenna to communicate with Earth. This antenna is similar to that under development for NASA's Tracking and Data Relay Satellites. A small (1 m) antenna on the despun portion of the Orbiter will be used to receive data from the Probe for relay to Earth.

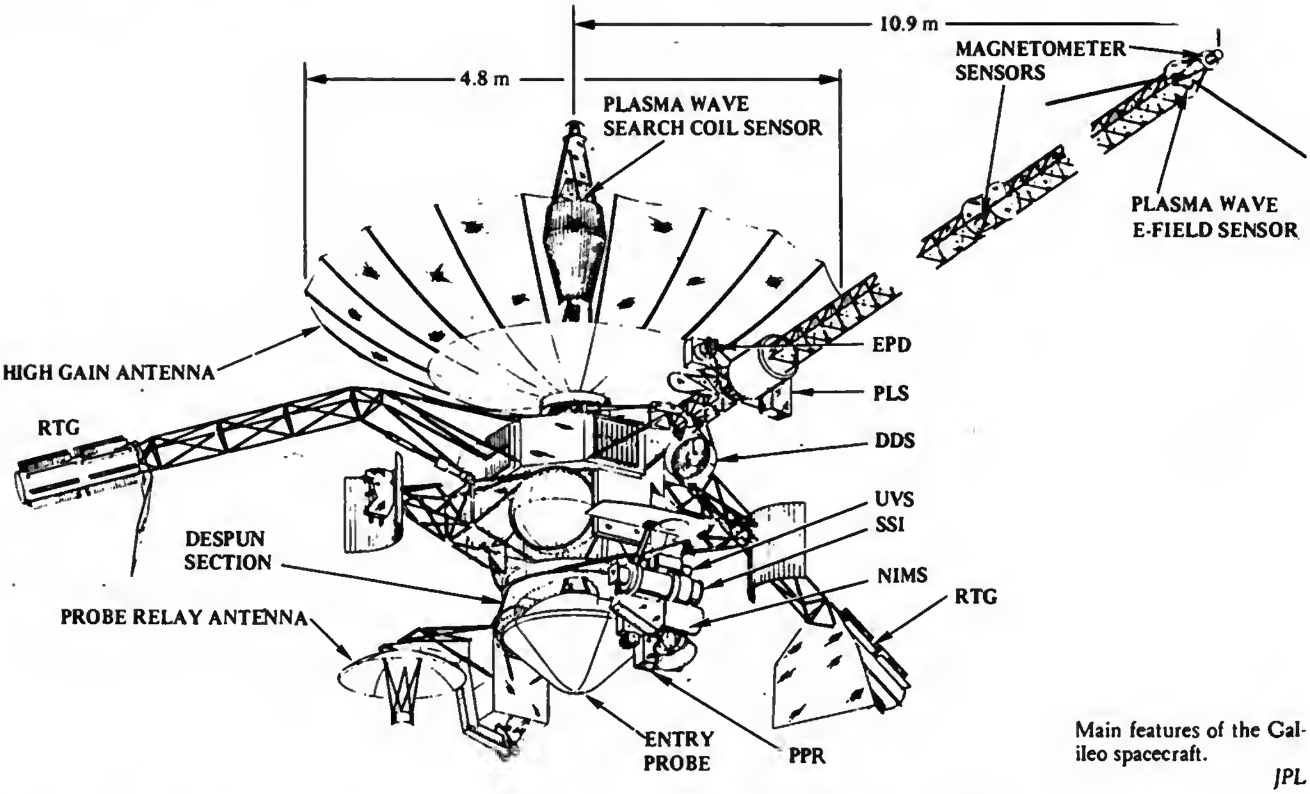
The RPM will be used for all propulsive and attitude control manoeuvres and consists of a 400 Newton engine plus two clusters of 10 Newton thrusters. Because of minimum burn size and total wetted lifetime constraints, the 400 Newton engine will be used only for the three major trajectory changes, i.e. deflection after probe release, orbit insertion and the perijove raise manoeuvre. All course corrections will be achieved by the use of the small 10 N thrusters. The RPM is being provided by the German Company MBB, under the management of the DFVLR.

The fields and particles instruments are carried either on the body of spinning section or, in the case of the plasma-wave and magnetometer sensors, on a long boom to remove them from the influence of the spacecraft structure. These instru-



The new route planned for Galileo involves re-encountering the Earth two years after launch.

JPL

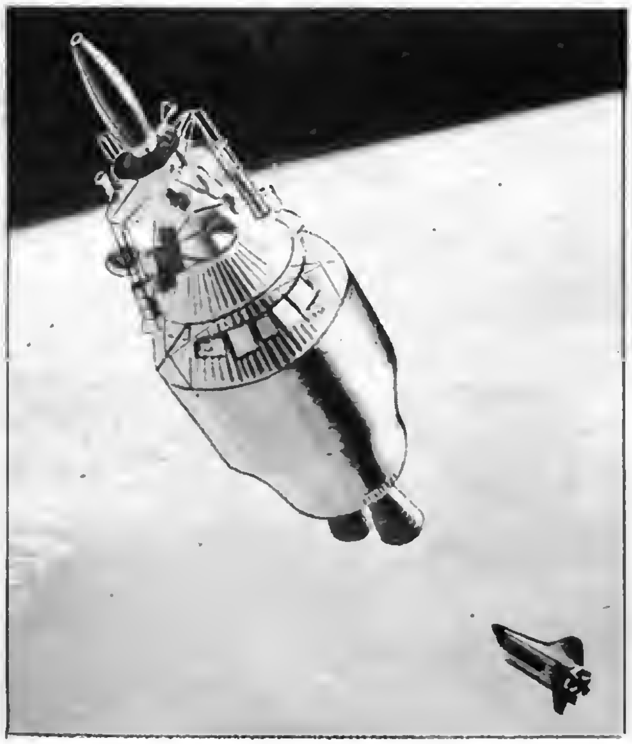


Main features of the Galileo spacecraft.
JPL

ments and their objectives are summarised in Table 1.

The despun section is a relatively small platform carrying the Probe data relay antenna and the four remote sensing instruments which require accurate pointing. These are described in Table 1.

The atmosphere entry Probe is designed to protect its cargo of seven scientific instruments as they penetrate the Jovian atmosphere and to decelerate them until they can be lowered gently through the atmosphere by parachute. It consists of a nearly spherical descent module surrounded by a two-piece aeroshell and heatshield, similar to the Pioneer Venus probes in external appearance. The heatshield makes up nearly half



An artist's concept of the launch at a time when the Centaur upper stage was included in the planning.

Table 2. Probe Science Investigations.

Instrument	Objectives
Atmospheric Structure Instrument (ASI)	Determine state properties (temperature, pressure, density and molecular weight) of Jovian atmosphere.
Neutral Mass Spectrometer (NMS)	Determine chemical and isotopic composition of Jovian atmosphere.
Helium Abundance Detector (HAD)	Perform precision determination of helium abundance measurement in Jovian atmosphere.
Nephelometer (NEP)	Determine microphysical characteristics (particle size distribution, number, density, and physical structure) of Jovian clouds.
Net Flux Radiometer (NFR)	Measure vertical distribution of net flux of solar energy and planetary emissions.
Lightning and Radio Emission/Energetic Particle Detector (LRD/EPI)	Study lightning in the Jovian atmosphere and energetic particles near Jupiter.
Radio Science	Study composition and structure of Jovian atmosphere.

of the total probe mass and is jettisoned after entry. The Probe is powered by internal batteries and remains inert throughout the cruise phase, being activated only a short time before entry into Jupiter's atmosphere.

No attitude control or propulsion is provided and the Probe must be accurately aimed prior to separation from the Orbiter. It will be spun at 10 rpm to provide stability during its coast and atmospheric entry.

The scientific experiments carried are described in Table 2.

Mission Profile

The launch of Galileo in its modified form is now expected to take place in May or August 1985, with the Shuttle Orbiter taking the craft and its 2-stage Inertial Upper Stage into low Earth orbit. The IUS will then ignite and accelerate Galileo to just below Earth-escape velocity. Since the IUS is a much less powerful stage than Centaur, Galileo must now carry an extra kick stage to provide adequate energy. The three-axis controlled Spacecraft Injection Module (SIM), using a hydrazine attitude control system and a Star 48 solid motor, will be attached to the bottom of the spacecraft stack.

After SIM burnout, the spacecraft booms will deploy and the SIM control system will begin a spin rate of 2-3 rpm. The SIM will then be jettisoned and Galileo will revert to its pre-Centaur cancellation configuration. But, instead of moving towards a direct encounter with Jupiter, Galileo will move in a 2-year period orbit that will bring it back to Earth in mid-1987 for a 200 km flyby in order to pick up enough energy for the trip to Jupiter. This "ΔVEGA" (Earth Gravity Assist) trajectory means that Jupiter encounter will not occur until 1990, and the less-favourable launch conditions dictate a more restricted mission once the craft is established in orbit about the giant planet.

About 5 months before Jupiter encounter the Probe and Orbiter will be separated. The RPM will then be used to deflect the path of the Orbiter onto its required trajectory. Each spacecraft will then proceed independently to Jupiter.

Four hours before the Probe begins its entry into Jupiter's atmosphere, the Orbiter will make its only close approach to the innermost satellite, Io. The Orbiter will pass within about 500 km of this volcanically active satellite. As well as detailed investigations of Io this encounter will provide an additional bonus for mission planners. The gravitation attraction of Io will slow the Orbiter, reducing the size of the Jovian Orbit Insertion burn required from the RPM. The Orbiter will not return to Io since repeated exposure to the intense radiation environment close to Jupiter could disable the spacecraft.

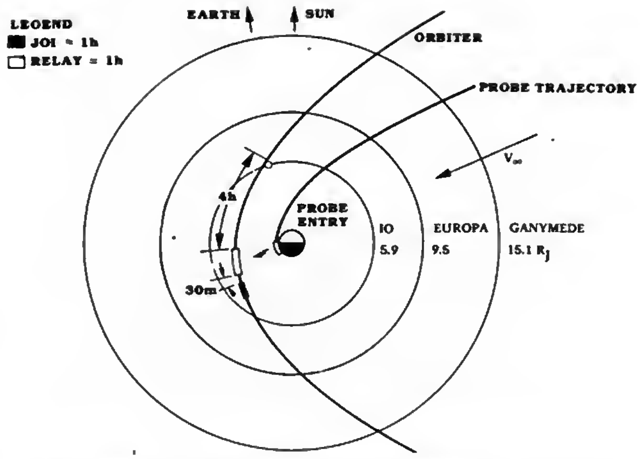
As the probe enters the atmosphere the Orbiter will be about 200,000 km above Jupiter's cloud tops. All of the data gathered from the probe will be transmitted to the Orbiter in real time for onward transmission to Earth.

As with Apollo re-entries the probe must accurately enter the Jovian atmosphere *via* a narrow corridor. Too steep an entry will produce intense deceleration and frictional heating which will destroy the Probe, too shallow an entry angle will cause it to skip back into space. This entry will, however, differ from Apollo in two very significant ways; the Probe will be travelling much faster than a returning Apollo and entering an atmosphere whose detailed structure is unknown.

It is intended that the probe will enter the atmosphere within 5.5 degrees of the equator, penetrating the high level equitorial zone. This will allow measurements of all Jupiter's significant cloud levels.

During entry the probe will decelerate at nearly 400g and the intense frictional heating will cause most the craft's protective heat shield to ablate away. The Probe will briefly appear as a bright red meteor flashing through the ammonia clouds.

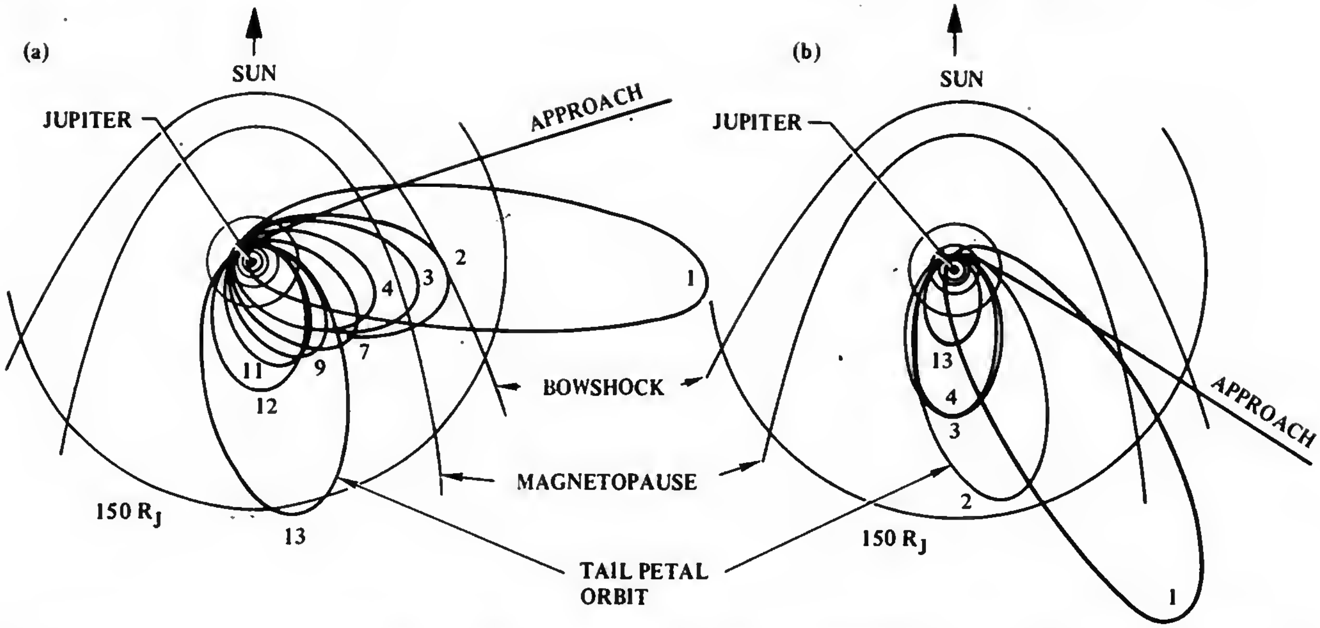
Shortly afterwards, the rear cover of the Probe will be jettisoned to allow deployment of the drogue parachute. This parachute will both stabilise the falling Probe and provide



The Probe and Orbiter trajectories close to Jupiter.

IPI.

Descent of the Probe into Jupiter's atmosphere. The drogue parachute (see illustrations on next page) opens at a height of about 90 km, and the heat shield detaches 45 km later. Data will be transmitted in real time to the Orbiter since the Probe is not expected to survive for much more than an hour.



The Orbiter will use its encounters with Jupiter's moons to change its view so that it can gain a more comprehensive picture of the system. The new mission profile may result in fewer orbital changes.

JPL

additional deceleration. A few seconds later the main parachute will be opened and the forward portion of the heat shield will be jettisoned to fall away into the depths of Jupiter's atmosphere.

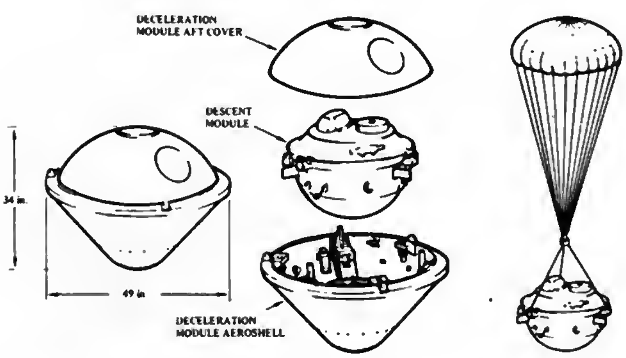
The entire entry operation will have lasted about two minutes and the Probe will then be suspended below its single parachute, and gently drifting down into the atmosphere. The battery of scientific instruments will begin their work of analysing the Jovian atmosphere, returning the results to Earth *via* the Orbiter as it hurtles overhead.

The operating life of the Probe will be short, probably only about an hour. As it descends, the pressure around it will increase and the temperature will rise. After about 40 minutes the pressure will have increased to ten Earth atmospheres and it will be below the lowest layer of water clouds. After an additional 20 minutes the pressure will have risen to nearly 20 Earth atmospheres and the probe will be reaching the end of its life. Eventually, it will be silenced by a combination of pressure, temperature and weakened radio signals.

Shortly after the Probe mission is completed the Orbiter will fire its 400 N engine in the RPM for the hour long insertion burn. The initial orbit will be highly elliptical, ranging from 200,000 to 15 million km.

For the next 20 months the Orbiter will carry out an intensive survey of the Jovian system. The basic mission before Centaur was dropped called for 11 orbits of the planet, including at least one close encounter of an inner satellite on each orbit. The new mission may now be able to achieve only six encounters. This will be achieved by using the gravitational field of the satellites to bend the Orbiter's trajectory each time a close encounter occurs. This allows a reduction in the amount of propellant required to achieve these multiple satellite encounters.

The precise orbital tour to be used is not yet decided, studies will continue until shortly before Jupiter arrival when the final plan will be chosen. If all goes well, there is a possibility that an extended mission could be flown until the spacecraft's propellants are finally exhausted.



The three stages of Probe configuration. Its design is based on the atmospheric probes of the 1978 Pioneer-Venus craft, some of which reached the planet's surface.

Conclusion

Galileo is a highly ambitious undertaking and a logical follow on from the successful Voyager missions. The wide range of instruments carried by the mission will allow an intensive investigation of the Jovian system over the nominal 20 month mission lifetime. To support the scientific programme 129 international scientists have been chosen, including several interdisciplinary scientists whose task will be to provide a link between the various experimenters. Every effort will no doubt be made to maximise the results of this mission, the only flight to Jupiter in the forseeable future.

Acknowledgements

We would like to thank Deborah Locatell, Executive Secretary of Project Galileo, for her invaluable assistance. The original material on the updated mission profile was written by William J. O'Neill, Galileo's Science and Mission Design Manager. Dr. Davies would like to thank Marylin for her assistance. Dr. Casani's paper "Galileo: Mission to Jupiter" was published by Pergamon Press.

THE MAIDEN VOYAGE OF "COLUMBIA"

By John A. Pfannerstill

PART TWO

Continued from the May issue

Getting Organised

After getting a "GO" for on-orbit from Mission Control Center-Houston (MCC-H), astronauts John Young and Robert Crippen began turning their spacecraft into a home for the next two days. Their first order of business was to get out of the cumbersome Emergency Ejection Suits (EES's). They put on lightweight blue flight coveralls, and began the task of shutting off many of the systems used to fly *Columbia*, while at the same time activating those which made it a habitable space dwelling.

While the astronauts were getting organised, engineers at MCC-H were studying a problem that had cropped up some 2½ hours earlier. As the crew opened the Payload Bay Doors (PLBD's), MCC-H received indications that one of *Columbia*'s three Development Flight Instrumentation (DFI) recorders was stuck in the running position. The malfunctioning recorder was specifically known as the Pulse-Code Modulation (PCM) recorder. Its job was to record engineering data throughout the flight in one of three operating modes:

1. Continuous record – the continuous recording of data with the tape running constantly;
2. Hi-sample – a ten-second sample of data taken every five minutes with the recorder stopping automatically between data takes;
3. Lo-sample – identical to Hi-sample only the ten-second data samples were taken every ten minutes.

There were six hours of tape available, and to ensure that the PCM recorder had enough to cover the entire mission, it was planned to operate it in the Lo-sample mode for most of the flight. The problem was that the recorder was stuck in the Continuous record mode, and the only way to avoid using all the tape was to pull the DFI PCM circuit breaker and shut the recorder down altogether. Since then, 2½ hours of valuable data had been lost.

MCC-H had a troubleshooting procedure prepared, and as *Columbia* came into contact with Hawaii at 16:26 on 12 April (all times are in GMT unless otherwise noted), capcom astronaut Daniel Brandenstein took the crew through it. It involved trying switches and circuit breakers in various combinations, but the efforts were fruitless, and the balky recorder was again powered down.

Bob Crippen in the galley/mid-deck area preparing food.

All photographs courtesy of NASA

Table 1 STS-1 Flight Plan Activities Mission Day 2

GMT	MET (DY/HR:MN)	ORBIT	EVENT
08:50	00/20:50	15	End sleep period
09:35	00/21:35	15	IMU Alignment
10:20	00/22:20	16	RCS Test Ignition #1
10:45	00/22:45	16	Meal period
12:00	01/00:00	17	TV of FCS Checkout - Part 2
13:00	01/01:00	17	Closed Circuit TV Checkout
14:22	01/02:22	18	RCS Test Ignition #2
14:30	01/02:30	18	PLBD Closing
15:22	01/03:22	19	RCS Test Ignition #3
15:35	01/03:35	19	Cabin Air Quality Test
16:15	01/04:15	19	PLBD Opening
17:00	01/05:00	20	Meal period
18:15	01/06:15	21	IMU Alignment
18:45	01/06:45	21	EES Donning/Seat Ingress
20:40	01/08:40	22	RCS Manual Rotation Tests
21:40	01/09:40	23	Meal period
22:45	01/10:45	24	CO_2 Absorber Replacement (TV)
23:40	01/11:40	24	IMU Alignment/COAS Calibration
01:00	01/13:00	25	Begin Sleep Period (7 hr 50 min)

Meal Period

While passing over the Indian Ocean and Australia on the fourth orbit, Young and Crippen ate their first meal aboard *Columbia*. On the menu were frankfurters, turkey tetrazzini, freeze-dried bananas, a candy bar and apple drink.

For this flight, *Columbia* was not equipped with the elaborate airliner-style galley it will have when it reaches operational status. Instead, Young and Crippen were provided with portable carry-on food warmers and surplus Skylab-type food. The astronauts were allotted three meals daily, each consisting of five or six foods and a drink or two. In addition, there were so-called "pantry" items, such as coffee, tea and snacks, which the men could have between meals if they wished.

After lunch, as *Columbia* began its fifth orbit, capcom astronaut Henry Hartsfield [1] informed Young and Crippen that the DFI PCM recorder would not be used to collect data during the two upcoming Orbital Manoeuvering System (OMS) burns. The two burns, known as OMS-3 and OMS-4, would be used to raise *Columbia*'s orbit from its current 133.5×132 nautical miles (nm) to 150 nm circular. The burns would be different from the first two OMS manoeuvres in that only one engine would be used for each. Normally, OMS burns are done by firing both engines together, but engineers wanted to see how well one engine would work by itself in the event

of its twin becoming inoperable on a future flight.

The OMS-3 burn took place over the United States, with the right OMS engine igniting precisely on time at 18:20:48. The 25.7 foot per second (fps) manoeuvre changed *Columbia*'s orbit to 148×131.7 nm.

OMS-4, which would be done on the left engine, was due to take place halfway around the world from OMS-3, as the Orbiter flew over the Indian Ocean. The engine ignited at 19:05, increasing *Columbia*'s velocity by 37.5 fps. The new orbit was a good one. Instead of the planned 150-nm circular path, the orbit was 149.3×147.6 nm. This was well within allowable tolerances.

RCS Jet Tests

Between 20:00 and 21:00, while *Columbia* was on its sixth orbit, Young and Crippen conducted an important test of the spacecraft's Reaction Control System (RCS). Using the 38 primary RCS thrusters and the six small vernier thrusters, the astronauts put the Orbiter into various attitudes in order to determine how well they could hold the attitude steady, and whether the jets consumed propellant at the predicted rates.

The 870 lbf primary RCS jets left a memorable impression on the astronauts. Whenever one of the thrusters fired, the men could see a 30 ft long plume of flame accompanied by a loud boom. They said later that it sounded like "muffled howitzers" firing just outside.

The RCS was remarkably efficient in attitude control, using 3 per cent less fuel than expected. The astronauts felt, however, that the racket from the primary RCS jets was so annoying that using them to hold attitude during sleep periods would make adequate rest nearly impossible. After the flight, Young and Crippen strongly recommended wider use of the more quiet verniers for attitude control, particularly during sleep periods.

Television Broadcast

During a nine minute pass over the United States on orbit 7, the astronauts transmitted more television from orbit, this time featuring views of themselves inside *Columbia*. At 21:22, when the picture flashed onto the screens in MCC-H, Young was seen in his seat on the flight deck giving a brief account of his ship's performance:

"Okay, the flight so far has gone as smooth as it can possibly go. We've done every test that we're supposed to do, and we're up on the time line, and the vehicle is just performing beautifully, much better than anyone ever expected it to do on a first flight, and no systems are out of shape . . . the vehicle is just performing like a champ. Real beautiful."

The view then shifted from the forward flight deck camera

A vertical view of the snow-capped Himalayas, taken during the STS-1 mission.

John Young in his Commander's seat. Note the three cathode ray tube displays towards the right.

to the aft camera, giving a picture of Crippen floating weightlessly up near the ceiling. The rookie space traveller said that he "had a thrill from the moment of liftoff all the way up to what we are doing now," and that "it has really been super."

After the 3½-minute telecast ended, capcom Hartsfield asked the men about mobility in the Orbiter in zero-G. Crippen said that it was much easier to get from the flight deck to the middeck than in the Shuttle Mission Simulator (SMS). "I can dash down there and back real quick," he said.

From the television show and the enthusiasm of their comments throughout the day, it appeared that Young and Crippen were thoroughly pleased with *Columbia* and that they themselves were having a good time.

First Sleep Period

According to the flight plan, the astronauts were due to start their first sleep period in space at 01:00 on 13 April. During the 7 hours and 50 minutes allotted for sleep, the men were to be strapped into their ejection seats on the flight deck. Since *Columbia* was a very noisy vehicle, Young and Crippen had acoustic blankets that they put on the floor to deaden the racket. They also had ear plugs that they could use if they wanted, although at least one of them was required to sleep with a communications headset on.

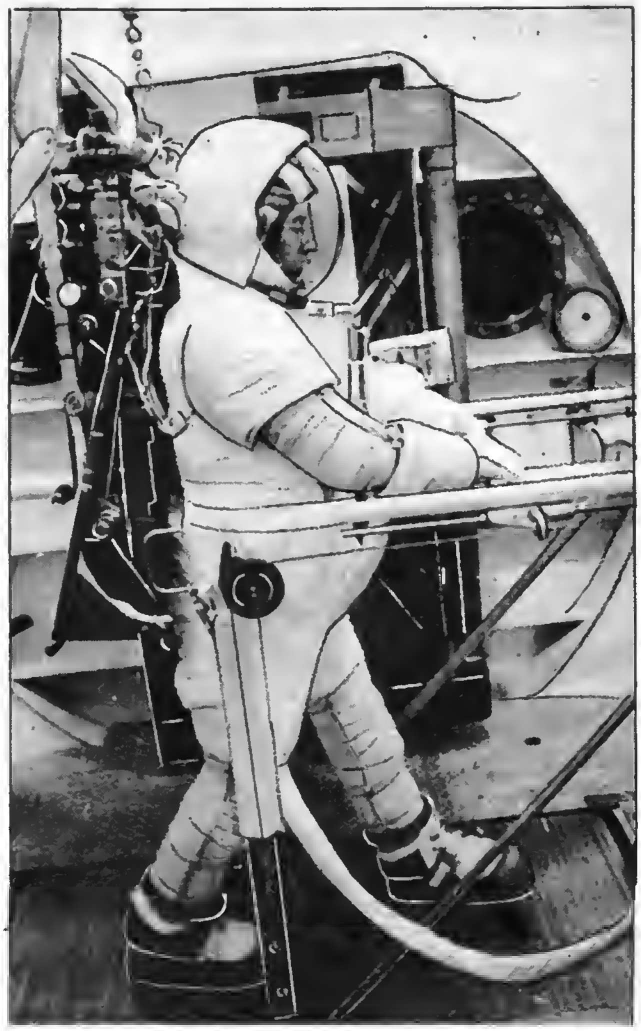
The astronauts found it difficult to get to sleep. They had been awake for over 18 hours, but their excitement was still high. The men spent some time relaxing by looking out of the windows, the first real opportunity they had had to do so. They had been so busy earlier that they had only caught fleeting glimpses of the spectacular sights outside.

Eventually they turned out the lights, put up the window covers and tried to get some rest. It was not easy. Young estimated that he slept for only three or four hours and Crippen did only slightly better.

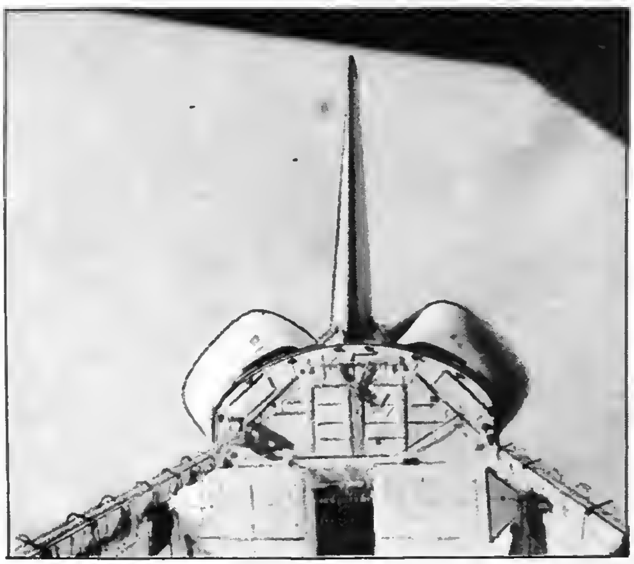
Second Day in Orbit

The astronauts received the first call of their first complete day in orbit at 08:43 while over Quito, Ecuador. Capcom Dan Brandenstein played some rousing wakeup music; a country/western tune called "Blastoff Columbia!" which had been supplied by astronaut Dick Truly and Flight Operations Director George Abbey.

Young and Crippen reported that the cabin had chilled down considerably during the night. Crippen said at one point that he was nearly "ready to break out the long undies." Brandenstein promised to send up a procedure to warm things up.



John Young, before the STS-1 mission, taking part in an evaluation test of the Shuttle EVA suit.



The view towards the flight data instrumentation in the cargo bay and the missing tiles on the OMS pods.

For much of the morning of their second day in space, the astronauts performed an extensive series of tests of their RCS thrusters. These were much like the attitude control tests of the day before. This time, however, the translational capability of the jets was being checked out. All told, there were five major burns of the primary RCS thrusters over a little more than seven hours. Interspersed with the tests were other activities, one of which was a gravity gradient drift exercise to examine how well *Columbia* could hold a steady attitude without using the RCS.

The gravity gradient exercise itself was fairly simple. At about 10:30, Young manoeuvred *Columbia* into a nose-down attitude using the RCS, and then left it there for just over three hours. During that time, there were no RCS firings to hold the craft steady. The astronauts were surprised at how well the scheme worked; *Columbia* kept remarkably stable.

This type of gravity-assisted attitude hold is being investigated as a possible means of keeping Orbiters stable on future long-duration missions in which RCS propellant would have to be conserved.

As *Columbia* drifted effortlessly around the world, Young and Crippen took time off for breakfast and some banter with capcom astronaut Joe Allen.

Flight Control System Checkout

After breakfast, the astronauts conducted a check-out of their Flight Control System (FCS). The purpose of this was to test the operation of the aerodynamic control surfaces on the Orbiter and the associated avionics in the cockpit. Live television of the two men on the flight deck during the test was also planned as *Columbia* came across the United States on orbit 17.

The TV picture appeared on the screens in MCC-H at 12:00, exactly 24 hours into the mission. Young was visible in his seat in the cockpit, wearing his half-frame reading glasses, and writing in his flight plan. Notebooks, seat belts and communications cables were floating everywhere, giving an unearthly quality to the scene.

Before the broadcast ended, the Orbiter flew right over the Kennedy Space Centre where it had started its mission one day before. The astronauts were able to see the centre easily and they quickly spotted the Vehicle Assembly Building (VAB) and the 15,000 ft Shuttle runway.

At 12:14, as *Columbia* came within range of the Madrid tracking site, there was more television, this time showing the Earth. The spacecraft's nose-down attitude provided an excellent view out of the forward windows. The astronauts had turned off all of the cockpit lights and aimed the camera outside. The view was spectacular, with the blue and white Earth framed by the dark outlines of the windows.

PLBD Closing

After *Columbia* came out of her gravity gradient drift, Young and Crippen continued with the RCS translation tests and other tasks. One of their assignments was to close the Payload Bay Doors, an important exercise. The doors had not been closed since they were opened over 24 hours before and engineers were anxious to see whether they would line up properly and close tightly after being open that long. There were fears that the doors could warp if left open for lengthy periods. The doors closed as easily this time as they had in the tests the day before. The flight plan called for them to remain closed for just under two hours before being opened again.

The astronauts were rapidly acquiring the knack of working aboard *Columbia* in weightlessness. Having so much room was not only new to space "rookie" Crippen, but also to veteran John Young. Although he had over 22 days of spaceflight time logged before this mission, the cramped confines of Gemini and Apollo had not allowed him anything like the roominess provided by the Shuttle Orbiter. The astronauts could easily turn weightless somersaults in the middeck area and they were able to effortlessly push off one wall and glide smoothly across the room to another.

"I'll tell you," Crippen told MCC-H at 15:40 while over Africa, "it's going to be tough to go back to work in the SMS (Shuttle Mission Simulator) one-g trainer after finding out how really easy it is to move around in this vehicle."

"I think you may be spoiled now," capcom Joe Allen said.

"You got it," Crippen shot back.

Vice-Presidential Chat

As *Columbia* arced across the Pacific Ocean at the start of its 21st orbit, the astronauts had lunch. Their meal included corned beef sandwiches, and Young received some of the expected good-natured ribbing from Allen and Crippen [2].

They finished their meal quickly since, during the next pass across the United States, they were scheduled to have a televised chat with the Vice-President of the United States, George Bush [3]. When *Columbia* came within range at 18:04, the TV camera was on, providing a picture of Young and Crippen floating around down in the middeck.

"John and Crip," Allen told them, "we have a telephone call coming into the space network from the White House for the crew members of the spaceship *Columbia* . . . if you would please, Mr. Vice-President, go ahead."

After opening greetings, Bush told the astronauts that their flight "is just going to ignite the excitement and the forward thinking for this country." He closed by telling the men that "we'll all be watching that reentry and landing with great interest."

The astronauts thanked the Vice-President for his good wishes, and then Joe Allen came back on the line. The incredibly clear views of Young and Crippen floating around doing acrobatics in the middeck prompted Allen to ask, "Crip, all of us very much rookies down here are wondering how you are enjoying zero-gravity flight. You look like you're enjoying it."

"You got it baby," Crippen replied, "you don't need any restraints, it's everything . . . right within your fingertips. You don't even need any back on the aft deck to work out the window."

Young added, "It sure would be nice to have some cordless mikes up here. That's the only thing you got to worry about (is) staying connected and not getting yourself wrapped around something."

The astronauts found the long communications lines from their headsets to be extremely annoying. They were constantly

Young cleans his razor after a shave. Note the food tray attached to the locker at right.

getting tangled up, creating a real nuisance. When they got back to Earth, Young and Crippen became strong advocates for the incorporation of wireless headsets on future missions.

EES Donning

The next item on the flight plan called for the astronauts to put on their Emergency Ejection Suits and climb into their ejection seats in a rehearsal for the reentry and landing. Young got suited first. He strapped himself into his seat, performed a communications check, then got out of the seat and the suit. Crippen then followed the same procedure, except that MCC-H had added a short procedure that they wanted him to try before he left his seat. It involved the troublesome PCM recorder, which was still not operating.

By this time, engineers at MCC-H had pretty well given up hope of getting the recorder to operate during the on-orbit phase of the mission. However, they still desperately wanted to have it running during reentry. It had been planned all along to run the recorder in the Continuous record mode during the descent, so the fact that it was stuck in that mode posed no problem. What had to be solved was how to turn it on.

The controls were located within easy reach of both pilots between the ejection seats. As mentioned previously, however, the controls had been ineffective in stopping the recorder, so it had to be deactivated at its circuit breaker. That circuit breaker was located behind Crippen's seat and to his right. Just before deorbit, when the recorder would have to be turned on, both astronauts would be suited up and strapped in; the breaker would be out of reach.

Crippen's backup pilot, astronaut Dick Truly, had spent much of the previous afternoon in the Shuttle Mission Simulator studying the problem and various ways of overcoming it. He finally came up with using a "swizzle stick" reach extender that the astronauts had on board to push the breaker in from Crippen's seat. He was able to do it quite easily, but he was in shirtsleeves at the time. MCC-H wanted Crippen to try it in his EES, which was expected to be more difficult.

Crippen gave it a try, but he reported that it was "extremely difficult" to do it in the suit. He was barely able to lay the end of the stick on the breaker, but there appeared to be no way he could put enough pressure on it to push the breaker in. He tried several times, but with the same result. It did not look like the "swizzle stick trick" was going to work.

Recorder Change

After the astronauts got out of their suits, *Columbia* flew for almost the entire 22nd orbit without any contact with a ground station. During this lapse of over an hour and a quarter, Johnson Space Center management and engineers met to decide what to do about the DFI PCM recorder; acquiring data during reentry was vitally important. Since it now appeared that the astronauts had exhausted all other means of getting the malfunctioning recorder to operate properly, the engineers came up with a bolder plan: replacement of the recorder itself. The crew did have a spare recorder and the proper tools on board with them.

At 21:17, when *Columbia* came back into contact over the US west coast on the 23rd orbit, capcom Henry Hartsfield informed the astronauts of the new plans. He said that the change would take about 90 minutes and that, to accommodate it, some low-priority items would be deleted from the flight plan.

To get to the recorder, the astronauts had to remove two floor panels from the middeck. Each panel was secured by 12 tightly torqued screws and this proved to be the main source of difficulty. It was difficult to get enough leverage in zero-g to turn the screws.

When *Columbia* came up on Hawaii at 22:45, Young and Crippen had the television camera running, giving MCC-H a picture of them hard at work trying to remove the panels.

"Okay Hank," Crippen said, "we've got a small problem, or a big problem, depending on how bad you want DFI."

'Okay, go ahead," Hartsfield said.

Crippen then gave the details: "Well, both John and I have been working pretty solid since the last time I talked to you and we don't have out half the fasteners yet, and I'm afraid I'm just not going to be able to get them ... They're just torqued in there so darn hard that we just can't get enough leverage to break them. I'm not even sure if I was in one-g I could break them. I'm just not sure this is going to be productive because we are going to end up spending at least four or five hours trying to do it."

After a quick discussion in MCC-H, flight director Chuck Lewis instructed Hartsfield to have Young and Crippen abandon the effort. It had been a noble try, but some other means had to be found to get the existing recorder to operate properly.

The remainder of the evening was very quiet. The astronauts had supper, performed some housekeeping jobs and prepared to turn in for the night.

At 00:46 on 14 April, *Columbia* came within range of the Santiago (Chile) tracking station. This was the last scheduled communications pass of the day, and would also be the last one of the flight for the "Bronze" flight control team. They were not scheduled to come back on duty again before the landing.

"On behalf of the Bronze team," Hartsfield said, "it's sure been a pleasure working with you troops. You've done a super job, we think it's been a tremendous effort on your part and we all look forward to seeing you (back in Houston) tomorrow. In fact, we're excited about it, we understand you're buying."

"Well, you may be right," Crippen said, "and we're sure sorry we couldn't fix that recorder for those guys. We'll be willing to consider not strapping all the way in (during reentry), and doing something like that if we can help them."

The final goodnight call to the crew came at 00:52 as the Columbia moved out of range of Santiago. Young and Crippen had had a busy second day in flight, and they would need a good night's rest for the even more demanding final day ahead.

To be continued

NOTES

1. There were three teams of flight controllers monitoring the STS-1 mission. Following a practice begun in the Apollo programme, each team was designated by a different colour. The "Silver" team was led by flight director Neil Hutchinson and had astronaut Dan Brandenstein as capcom, the "Bronze" team was headed up by Charles Lewis with astronaut Henry Hartsfield handling spacecraft communications, and the "Crimson" team had Don Puddy as flight director with scientist-astronaut Joe Allen as capcom. Each team was made up of roughly 20 people in the control room proper along with dozens of others working in support rooms down the hall from the main control room. Extensive use of computers on the later operational Shuttle flights will cut the number of controllers required to monitor a flight to just a handful, but for this first mission, the control room was just as full as it had been during the Apollo days.
2. Back on his first space flight (Gemini 3 in 1965), Young smuggled aboard an unauthorised corned beef sandwich as a little surprise for his commander, the late Virgil (Gus) Grissom. Young had not intended for anyone to ever know about his joke but word leaked to the press, and before long, some NASA officials and even some members of Congress expressed outrage at Young's "irresponsible" attitude toward the Gemini medical experiments programme which they evidently felt would be destroyed by a single bite from a corned beef sandwich. Young received an official reprimand from his superiors, but unofficially, everyone thought he had pulled off a pretty good joke.
3. President Ronald Reagan was still recovering from the bullet wounds he suffered in the assassination attempt of 30 March, and was unable to talk to the astronauts himself.

SPACE COMMUNICATIONS

DIRECT BROADCASTING

Following the Home Secretary's House of Commons announcement on 4 March, on the go-ahead for direct broadcasting by satellite, the following statement was jointly issued by British Aerospace, Marconi and British Telecom:

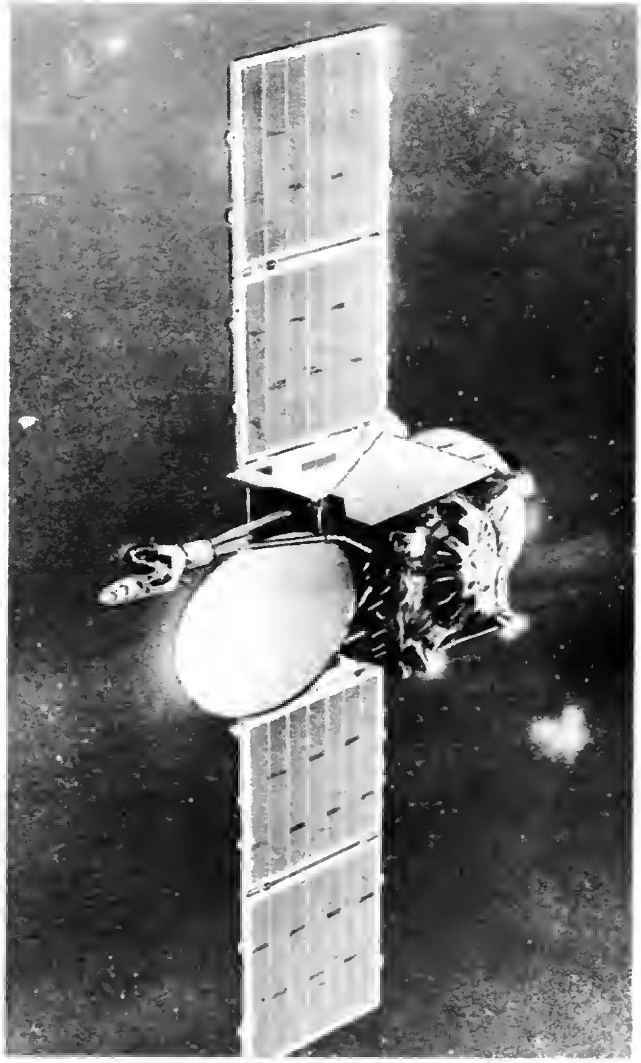
"British Aerospace, Marconi and British Telecom plan to form a joint company – United Satellites – to provide Britain's first national broadcasting and telecommunications satellite system.

Welcoming the Home Secretary's announcement today of the Government's policy on direct broadcasting by satellite in Britain, British Aerospace, Marconi and British Telecom confirmed that they were planning a British satellite system to provide facilities for direct broadcasting and telecommunications services from the mid-1980's.

The three companies have already investigated potential markets, and also the technical and operational means to meet broadcasting and telecommunications requirements in both the short and long term. Their preliminary work has already involved liaison with Government departments and with broadcasting and other organisations. British Telecom has, in addition, advised on the development of national and international satellite telecommunications services from the mid-1980's.

In the next phase, the three companies will be having further discussions with the broadcasting organisations to define technical requirements and the terms on which they will be able to offer satellite capacity for direct broadcasting television services. The requirements for satellite telecommunications services will also be finally agreed with British Telecom.

Through their collaboration, the three parties propose to become the suppliers of the first British national system for direct broadcasting and telecommunications services by satellite, as well as promoting British satellite systems and services successfully in expanding world markets."



Japan's Broadcasting Satellite 2 (BS 2) will be used for operational domestic broadcasting of two colour TV channels. BS-2a will be launched in February 1984, with its BS-2b backup being launched in August the following year.

NASDA

INSAT-1 LAUNCHED

The first generation Indian National Satellite System (INSAT-1) spacecraft was launched by a Delta 3910/PAM from Complex 17A of the Eastern Space and Missile Center in Florida on April 10. The multi-purpose telecommunications-meteorology spacecraft was built to provide a capability for nation-wide direct broadcasting to community TV receivers in rural areas.

Initial indications were that the main antenna had failed to fully deploy. Attempts were underway at the time of writing to correct the problem but, if unsuccesful, the $130 million satellite could be used for only the meteorological portion of its mission.

Its orbital location will be 74 degrees east longitude above the Earth's equator. A sister spacecraft INSAT-1B, scheduled for a July 1983 launch on Space Shuttle, will occupy a similar equatorial location at 94 degrees east longitude.

Both spacecraft are built by the Ford Aerospace and Communications Corporation under a joint venture of the Department of Space, the Posts and Telegraphs Department (P & T) of the Ministry of Communications, the India Meteorological Department of the Ministry of Tourism and Civil Aviation and Doordarshan of the Ministry of Information and Broadcasting.

INSAT spacecraft are designed to provide the following communications services over a seven year orbital lifetime:

1. Twelve transponders operating over 5935–6425 MHz (Earth-to-satellite), 3710–4200 MHz (satellite-to-Earth). Used for thick route, thin route and remote area communication and TV programme distribution.

2. Two transponders operating over 5855–5935 MHz (Earth-to-satellite) and 2555–2635 MHz (satellite-to-Earth). Used for direct television broadcasting to augmented, low-cost community television sets in rural areas, radio programme distribution, national television networking and disaster warning.

For meteorological purposes, a Very High Resolution Radiometer (VHRR) instrument with visible (0.55–0.75 micron) and infra-red (10.5–12.5 micron) channels has resolutions of 2.75 km (1.5 mi) and 11 km (6 mi) respectively with full Earth coverage; full frame imaging every 30 minutes.

The meteorological system will provide:

1. Round-the-clock, half-hourly, synoptic observations of weather systems including cyclones, sea-surface and cloud-top temperatures, water bodies, snow cover, etc., mapping the

entire territory of India as well as adjoining sea and land areas.

2. Collection and transmission of meteorological, hydrological and oceanographic data from unattended remote automatic data collection platforms (DCP's) to a central data processing centre.

3. Timely warning of impending disasters from cyclones, floods, etc., and dissemination of meteorological information for agricultural and other purposes. Using the INSAT television capability, the warnings can directly reach the population in the areas likely to be affected.

Communications Satellite 2 (CS-2) is another Japanese satellite under development. CS-2a will be launched in February 1983 to provide domestic communications, with CS-2b as a backup. Each will be able to handle 4,000 telephone calls.

NASDA

SPACE AWARD

The Eighth Marconi Fellowship for communications science and technology has just been awarded to Arthur C. Clarke for his contributions to the concept of communications satellites. The presentation will take place at the Hague on 11 June.

Arthur, a past Chairman of the BIS and a long-standing Fellow, plans to apply a major part of the accompanying $35,000 grant towards the proposed Sri Lanka Centre for Communication, Energy and Space Technologies at the University of Moratuwa, near Colombo, of which he is currently Chancellor.

The previous seven Fellows include Dr. James Killian and Dr. Seymour Papert of MIT, Professor Arthur Schawlow (co-inventor of the laser), Dr. John Pierce (father of Telstar) and Professor Yash Pal (director of the Indian educational satellite programme, and now Director General of the UN Conference on the Peaceful Uses of Outer Space).

SPACE-DEVELOPED AMPLIFIER

A compact radio wave amplifier invented by Dr. Henry Kosmahl of NASA's Lewis Research Center in Cleveland, may benefit UHF television stations around the world by reducing their electrical power requirements significantly.

The device is a "multi-stage depressed collector" and was originally invented by Kosmahl to improve communications satellite efficiencies. It is used to increase the intensity of the radio signals transmitted by communications satellites without increasing their electric power consumption, a real benefit for solar cell-operated spacecraft. The device can also be used for terrestrial microwave or ultra high frequency (UHF) television transmissions.

A 200,000 watt UHF television station in a medium to large metropolitan area in the United States requires about £150,000 worth of electricity per year to stay on the air.

The application of the multi-stage depressed collector to transmitter amplifier tubes now installed at UHF stations could reduce their electric consumption by as much as a third to a half. Installation and equipment charges are expected to pay for themselves in one year.

UHF television stations presently use devices called klystrons to generate and amplify the ultra high frequency current (the broadcast signal). Klystrons are vacuum electronic tubes which operate at efficiencies of only about 10 to 15 per cent. By modifying the klystrons to include the multi-stage depressed collector, efficiencies of up to 30 per cent are achievable. These higher efficiencies reduce power consumption levels correspondingly.

Kosmahl estimates the cost of converting the device to work with UHF transmitter klystrons at about £500,000 and would involve a development programme lasting about three years.

Kosmahl invented the device in 1969 and was awarded a US patent in 1972. An experimental model of the electron beam device, fabricated by Litton Industries, was launched aboard the Communications Technology Satellite in 1976 for a 3½ year test managed by the Lewis Research Center. During that period, it produced the most powerful radio signals ever transmitted from space and beamed broadcasts to smaller, low-cost antennae sited in remote areas of the United States and Canada.

Communications satellites use microwave frequency amplifiers that generate radio waves for transmission to Earth antennae. These amplifiers are, however, able to convert only about 20 per cent of available electricity into radio waves. The remaining 80 per cent becomes waste heat within the satellite and must be dissipated by cooling.

Kosmahl's device, however, recaptures this waste energy, uses it to strengthen the microwave signal and reduces on-board heat. Because of this heat reduction, the cooling system is smaller and less complicated.

The device consists of a series of concave electrodes that recover electrons of varying velocities just before they have spent their energy. The collector not only sorts out electrons by velocity but also slows them and prevents them from streaming back into the tube.

The device can, after some modification, be applied to any microwave power transmitting device to improve its efficiency. In Japan and Great Britain, similar devices, based on US technology, are already widely used with UHF television transmitters.

"Astronautics History" JBIS

One aim in founding these *JBIS* issues devoted to "Astronautics History" was to offer an outlet to students to help them to advance their studies. Very few professional journals, anywhere in the world, encourage or accept articles from students in this way.

This is why we would like to see many more contributions from students. A practice often met with in the USA is for a professor to encourage a promising student to publish by collaborating with him on an article. Members of the UK teaching profession might also consider this as a useful means of publishing useful information which adds to the total knowledge of the history of astronautics.

We would like to see more contributions and cordially invite representatives from every nation capable of documenting its contribution to the science and engineering of rocketry and space travel to offer to do so via the medium of our publication.

M. R. SHARPE
Editor, "Astronautics History", *JBIS*

THE ORIGINAL VOYAGER

By Curtis Peebles

A MISSION NOT FLOWN

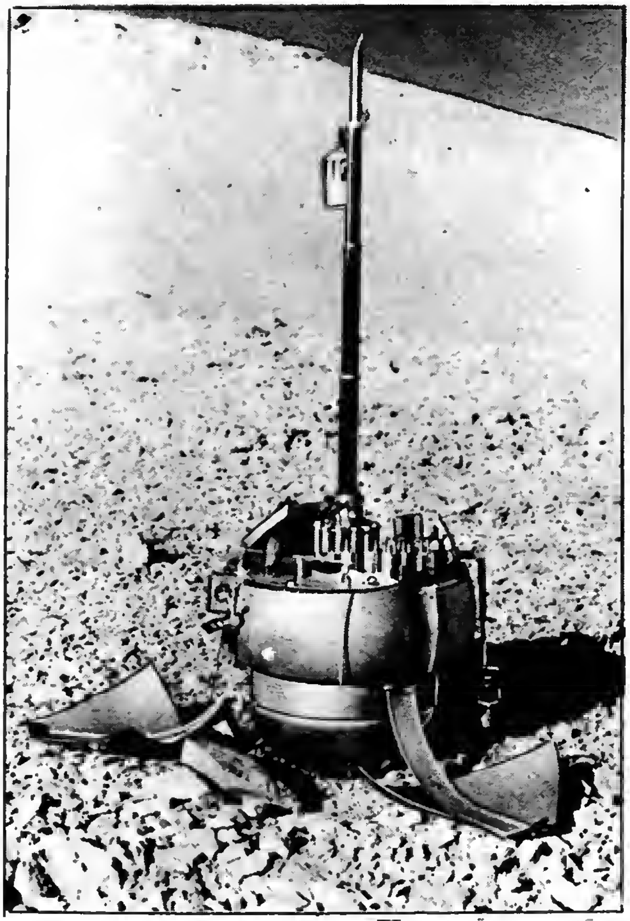
The US planetary exploration programme presently faces an uncertain future. The beginning of the decline could be said to have begun with the fall of the original Voyager programme. This was not the Voyager of Jupiter and Saturn but an earlier programme that would have gone to Mars. The original Voyager was the most expensive and ambitious unmanned programme ever proposed.

Early Studies

In the early 1960's, the time was right for the exploration of Mars. Hydrogen fuel boosters, US Soviet space rivalry and favourable launch windows in 1969 and 1971 all came together to make it possible in [1].

The Voyager programme began in 1960 as a planning objective of the Jet Propulsion Laboratory. Biological studies played a key role; the lander was to be equipped with an Automated Biological Laboratory that would look for energy transfer and conversion, macro-molecules, reproduction and growth, substances associated with Earth life and evidence of molecular organisation in [2].

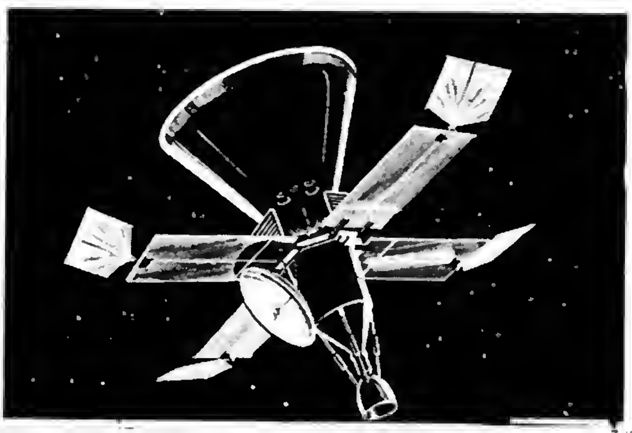
In 1964, the space science board of the National Academy of Sciences stated that life on Mars was possible and that a high priority programme should be established to study it in [3]. Others were not so sure. Dr. Barry Commoner, from Washington University, said at a meeting of the American Association for the Advancement of Science that because there was no liquid water on Mars, there was no reasonable chance of life and therefore no need to go looking for it. He accused the board of over-rating the possibility in [4]. NASA responded by saying that life was at least possible so that the emphasis was on biology in [5].



Mars rough lander designed by the Philco Corp. in the early 1960's. The sphere was 68 inches (173 cm) in diameter and weighed 1,200 lb (544 kg). It was to be equipped for a full scientific and biological survey of the landing site. After touchdown, the sphere would right itself and extend the central mast. Small rocket darts trailing wire would be fired. The soil sampler could travel back and forth along these wires to pick up material for analysis.

Technical Features and Re-orientation

Voyager was to be a three part spacecraft launched by Saturn 1B/Centaur. The spacecraft bus carried the solar panels, the radio dish and the experiment package. Weight was to be approximately 1,800 lb (816 kg). The retro-propulsion system contained the rockets and fuel tanks for attitude control, mid-course correction and Mars orbiting insertion. The unit weighed between 2,200 and 4,400 lb (998 to 1,995 kg). The third part was the capsule/lander; shaped like the Apollo Command Module, and its weight ranged from 1,000 to 6,000 lb (454 to 2,722 kg) depending on the specific mission. After the heating phase of atmospheric entry, the lander would separate and be lowered to the surface by parachute.



An artist's conception of the complete pre-Mariner 4 Voyager. The three part construction is apparent.

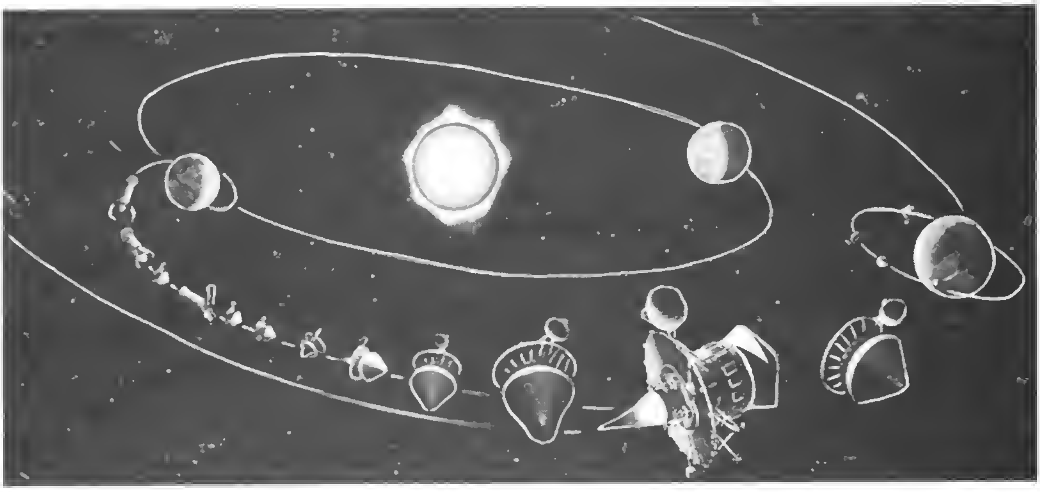
Two Voyagers were to be launched during every Mars launch window from 1969 to 1977, each more complicated than the last. Total cost of the programme would be $1,000 million.

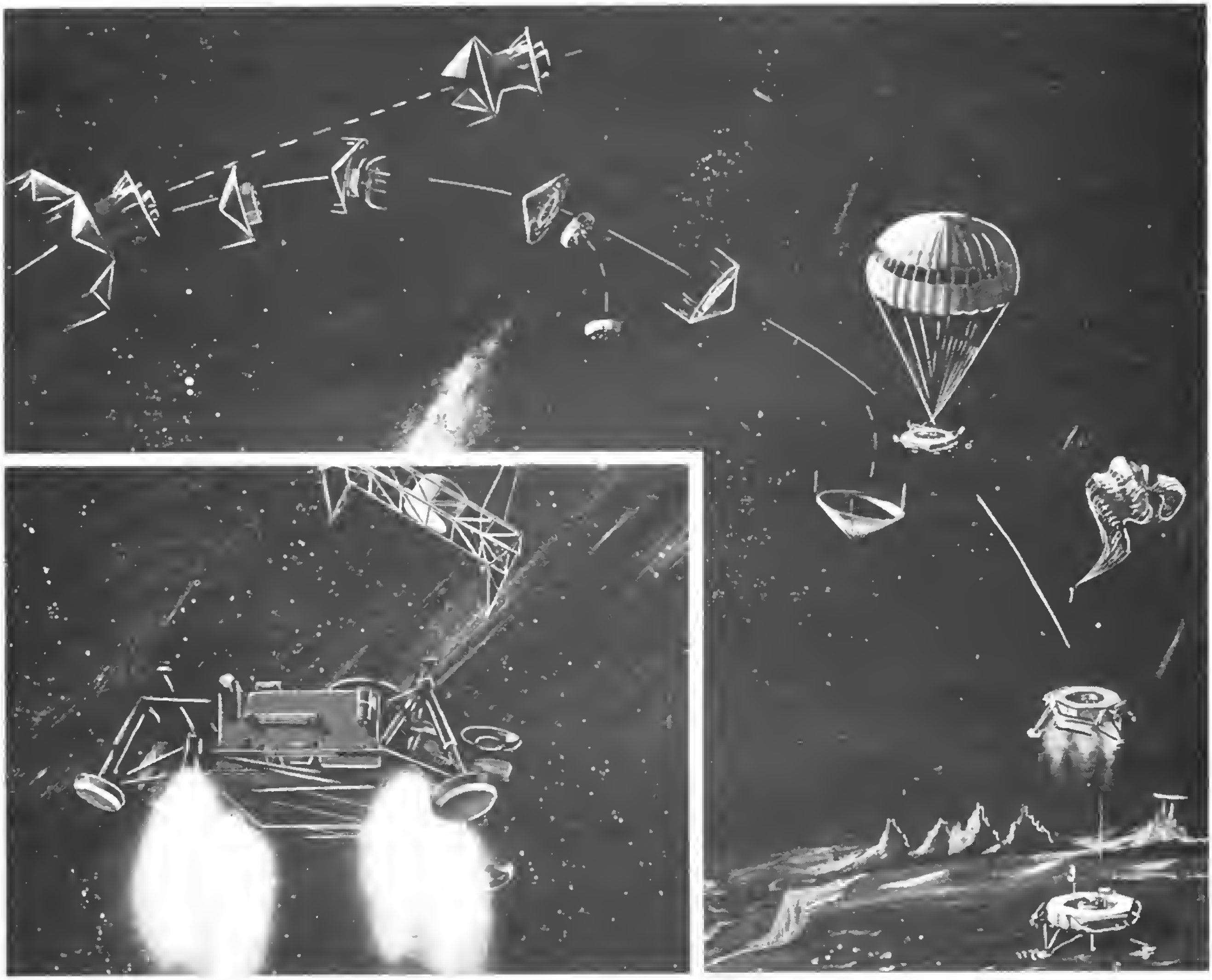
On 14 July 1965, Mariner 4 flew past Mars, sending back results that were devastating to Voyager. The capsule design was based on a 10 or 11 millibar pressure at Mars' surface but when the atmospheric data was analysed, it indicated only 5 to 7 millibars – too low for parachutes to be used all the way to the surface. This meant a retro-system would have to be included on the lander and the atmospheric entry path would have to be more shallow.

There was another effect, less easily measured. The photographs that Mariner 4 returned gave the impression that Mars was much like the Moon – barren, desolate and, of course, sterile.

By the end of 1965, Voyager had entered a two year period of re-designing. Unspent funding was redirected to revitalise

Earth-Mars trajectory for Voyager.





Landing sequence for Voyager. The bioshell opens and capsule separates. The capsule's retro-rocket system fires, then separates. The capsule orients itself and enters the Martian atmosphere. After the heating phase, the parachute deploys and the lander separates. The terminal descent system lowers it to the Martian surface. *Inset:* the lander separates from the parachute harness. The shape of the lander is similar to that of Viking except there are four legs. Other concepts were like the Surveyor.

Martin Marietta

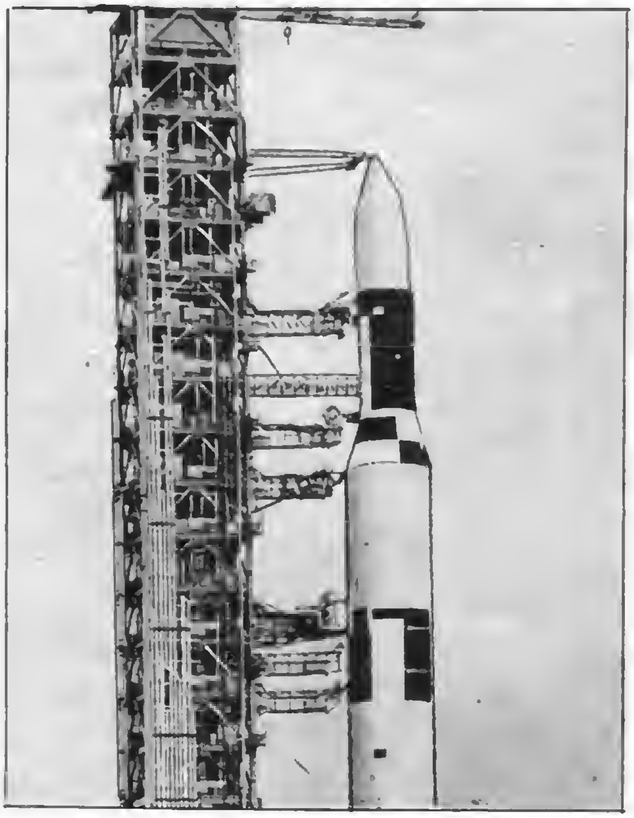
the Mariner programme. This provided for a mission to Venus in 1967, a dual fly-by of Mars in 1969 and, in 1971, two Mars orbiters [6, 7].

The New Voyager

The post-Mariner 4 Voyager was about triple the weight of the earlier version. It still, however, retained the three part construction. The capsule's shape was flatter, more disc-like. Total capsule/lander weight was about 5,000 lb (2,268 kg); later mission weights could go to 7,000 lb (3,175 kg). Unlike the earlier version, the capsule would remain attached to the bus when it entered orbit. The lander would weigh 860 to 1,500 lb (390 to 680 kg) and was similar in design to the Surveyor Moon lander. The bus weighed 2,500 lb (1,134 kg) empty and the greatest increase was in the retro-propulsion system. It now weighed 13,000 to 15,000 lb (5,896 to 6,803 kg) due to the capsule being retained in orbit. Total weight would be 20,500 to 24,500 lb (9,298 to 11,113 kg).

A pair of Voyagers would be launched aboard a single Saturn 5 in missions flown in 1973, 1975, 1977 and 1979. Total programme cost had climbed to $2,400 million; money was becoming a central issue for Voyager.

In early March 1966, the House Space Science and Applications sub-committee issued its recommendations on the NASA budget. It urged that Congress take a larger role in determining the scope and direction of the space programme. It proposed that Mariner Venus 67 be cancelled and the $42 million be used to speed up the exploration of Mars. $20 million would be added to the Mariner Mars 69 project and $22 million to the $10 million Voyager request. When the NASA budget for 1966 was finally approved that summer, the 1967 Venus mission had survived and $13 million was added to Voyager on [8,9].



The Saturn 5/Skylab launcher. If Voyager had flown, its Saturn 5 would have looked very similar, with the shroud covering two craft.
NASA

When the Voyager budget came up for Congressional action in 1967, it faced a far different reception. In the six years since President Kennedy had launched America toward the Moon, much had changed. The cold war had faded, Kennedy was dead, the Vietnam War was stirring protest marches and cities were torn by race riots. That January the Apollo fire had killed Grissom, White and Chaffee. Under such conditions, the NASA budget made a tempting target. The Voyager request totalled $71.5 million. When the NASA budget emerged from the House and Senate space committees, it had undergone major cuts. Mariner Mars 71, Sunblazer, the Voice Broadcast Satellite, the large solid fuel rocket programme, the Electronic Research Center, Apollo Application Program and Voyager had all been hit[10]. The House committee had reduced the Voyager authorization to $50 million and the Senate committee had eliminated it entirely. On the floor of the Congress, the debate was set in terms of health care, food and the city problems *versus* space. The differing House and Senate bills had to be reconciled in committee and Voyager was one area of contention. The House members wanted funding restored, while Senate members were willing to provide some funding to Voyager if the House would agree to larger cuts in the Apollo Applications Program in [11]. Voyager emerged with $42 million in [12].

On 18 August 1967, the House eliminated all funding for Voyager. The NASA authorization bill had been cut by $516 million, meaning that the US space programme had been reduced to Apollo only. The AAP programme was limited in scope and the planetary programme curtailed severely. Beyond the mid-1970's, there were no authorised programmes. To keep Mars exploration alive, NASA could propose that Voyager be delayed until 1975 or a small orbiter/lander could be developed for launch by a Titan III Centaur. The first option was not realistic and the other ran the risk of irritating Congress after it had cut a planetary programme. However, the second option was selected, ultimately to become Viking.

Conclusions

The reasons for Voyager's failure are simple enough: it got underway before enough was known about Mars. With re-orientation, the price exceeded what Congress was willing to pay. Lost with Voyager was a chance to conduct long term exploration of Mars. The US planetary programme continued but political factors took their toll. Costs for the Shuttle are often blamed but the reasons went deeper: the emphasis of Earthly applications and the turning inward that affected American society throughout the 1970's. In any event, it became gradually harder to get approval for planetary missions.

One such casualty was the Grand Tour mission that would have flown to all of the outer planets. Its cost was also too high. Its replacement was the Mariner Jupiter Saturn mission which, shortly before launch, was renamed Voyager.

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Editor's Note: the full version of this article can be found in the January 1982 "Space Chronicle" issue of JBIS.

NEWS FROM THE CAPE

By Gordon L. Harris

FIFTH SHUTTLE ORBITER

Vice President George Bush has been drawn into the novel proposal to buy a fifth Space Shuttle Orbiter by an investment company. Meanwhile, as part of the FY 1983 budget hearings in Congress, NASA is looking into ways of revamping its contract with Rockwell International to add that fifth craft. Former President Carter knocked the fifth Orbiter from the programme. *Challenger* will join *Columbia* this year, *Discovery* comes on line in 1983 and *Atlantis* in 1984.

Charles C. Lee, board member of Space Transportation Co. Inc., wrote to Bush suggesting that the Vice President meet company executives to hear their proposal. Bush replied on 9 November 1981 as follows:

"Dear Charlie:

Thank you for your letter and the accompanying prospectus of your company's proposal for private industry funding of the fifth and possibly successive space shuttle orbiters.

"Your proposal is extremely intriguing. As you know, President Reagan is strongly committed to maintain the US leading role in space and also encouraging greater scope and initiative of private industry in many areas. Your proposal is very much in keeping with these ideas. Unfortunately my schedule is extremely crowded at the moment and I do not believe it will be possible to meet with Dr. Heiss and Mr. Sword for a briefing in the foreseeable future.

"However, as you may be aware, the President's Science Adviser G. Keyworth and his staff are currently conducting a major space policy review including options for the shuttle program. It occurs to me that your proposal fits in perfectly with their work and could make a valuable contribution to the study. I have taken the liberty of passing your proposal along to him and I have asked that his office contact you about it."

Dr. Klaus Heiss is president of Space Transportation Co., sponsored by William Sword, an investment banking firm. The firm submitted a formal proposal to NASA offering to buy a fifth Orbiter and turn it over to the government in 1985 in exchange for exclusive commercial marketing rights for the entire fleet.

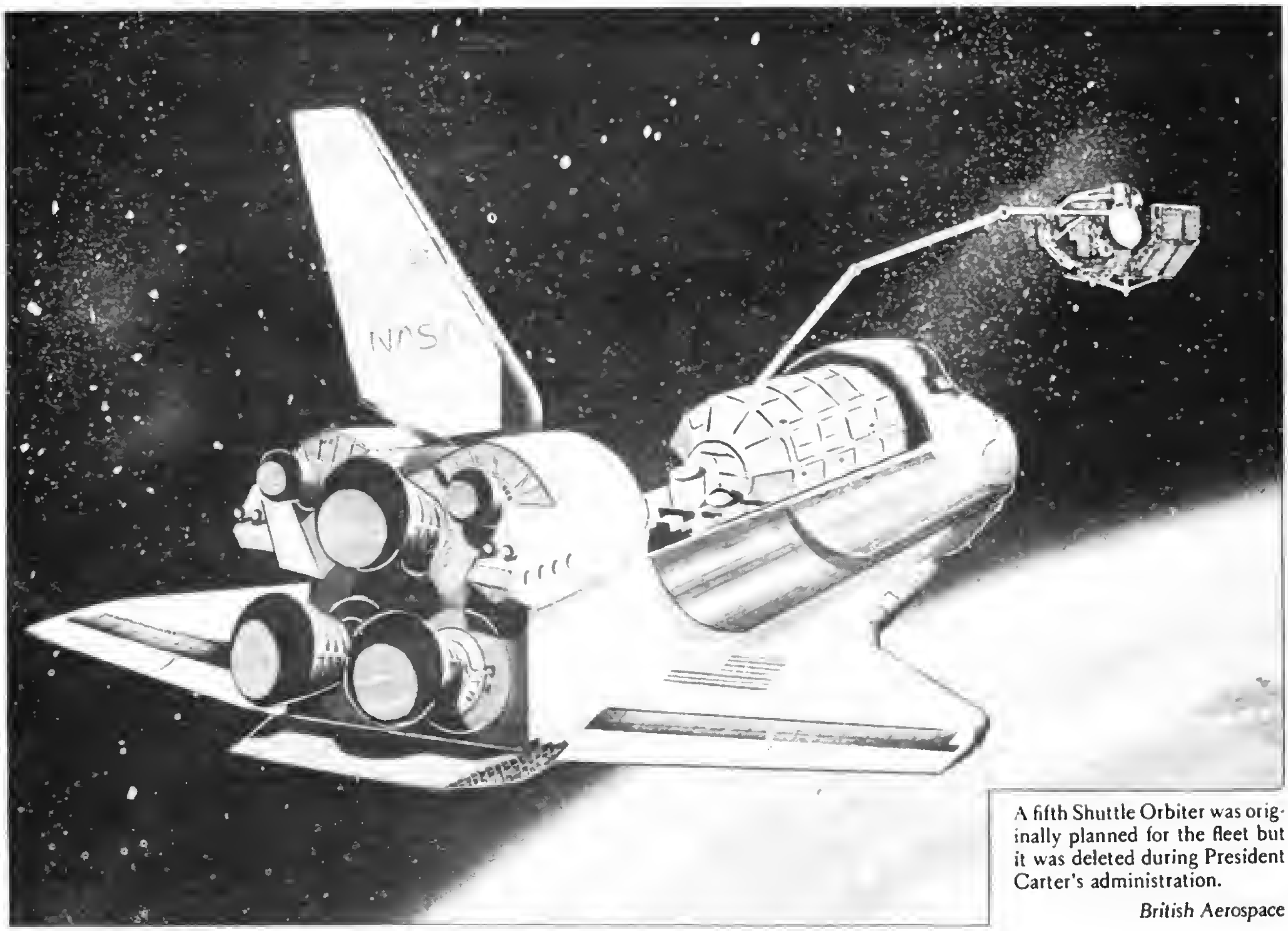
The company would spend $1,000 million to purchase the ship and pay a $150 million down payment. NASA has estimated that profits over a 10-year period could be $2,000 million.

Sword and Heiss wrote a second letter to Bush stating in part: "We believe initiatives toward larger private participation in space in the spirit of free market and free enterprise would be crucial to the future success of the US technology base in space matters."

Heiss briefed the House Subcommittee on Science and Applications. Rep. Harold Hollenbeck wrote to Bush asking for an explanation of his interest in the proposal.

Earlier, company officials said that they seek only to market the Shuttle fleet for commercial users and do not intend to become involved in such operational aspects as launch, tracking, landing and refurbishment.

One Orbiter of the present fleet will operate from Vandenberg Air Force Base in California to insert military satellites in polar orbit; Air Force sources have talked of a 10-launch rate annually. Other Shuttles will be launched and landed at Kennedy Space Center, on Florida's east coast.



A fifth Shuttle Orbiter was originally planned for the fleet but it was deleted during President Carter's administration.

British Aerospace

STS-4 PREPARATIONS

Reducing turnaround time for *Columbia's* fourth flight by 34 working days was held out as a definite possibility by Donald Phillips, chief, integrated tests, in a press briefing on 19 March. The decision to land STS-3 at White Sands in New Mexico because of rain-soaked runways at Edwards Air Force Base in California, was expected to delay the ship's return to Florida by at least four days.

Phillips displayed graphs indicating the number of working days expended on *Columbia* for all three test flights: 668 days for STS-1, much of which really belonged to manufacturing time performed at the launch base; 187 days for STS-2, 97 days for STS-3 and a planned total of 64 days for STS-4, working towards a possible launch on 27 June.

His figures disclosed that *Columbia* occupied the Orbiter Processing Facility 531 days prior to STS-1. The ship was missing some 20,000 of 33,000 tiles when it reached the Cape. Most of that long delay was taken up in applying and reapplying tiles of the thermal protection system. By contrast, *Columbia* was in the OPF only 99 days before its second launch, 55 days for STS-3 and a planned 25 days for STS-4. While the assembly process in the Vehicle Assembly Building required 33 days for the first mission, the interval dropped to 18 days for the second and 12 days for STS-3. Only 10 days are planned for STS-4.

NASA told newsmen costs reach $1 million per day when the fully assembled vehicle occupies the launch pad. Keeping that in mind, Phillips reported 104 days for STS-1, 70 for the second mission, 30 for STS-3 and said that might be further reduced to 29 for the June flight.

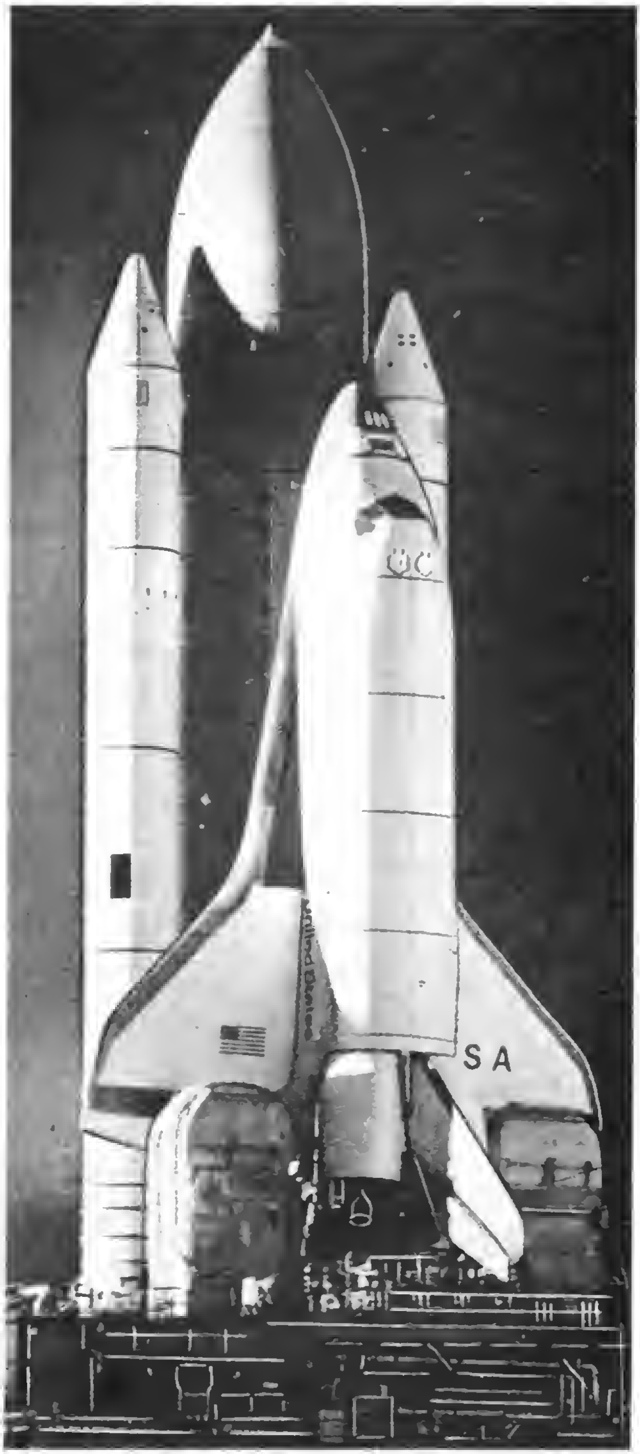
Before the launch of STS-3 on 22 March, Launch Director George Page also said that turnaround could be further reduced for *Columbia's* fourth and last development flight. Instead of a mid-July launch, Page suggested the ship could be ready by 27 June. Eliminating some tests and shortening stay time in the assembly building could advance STS-6, the first operational flight, and the initial launch of *Challenger*, the second orbiter, to early January 1983. *Challenger* should reach KSC in late June.

Pilots and mission specialists for STS-4, 5 and 6 have been selected. Thomas F. Mattingly, commander, and Henry W. Hartsfield, pilot, will fly the last test mission for seven days and land at Edwards Air Force Base in California.

Columbia's first operational mission in mid-November will be flown by Vance D. Brand, commander, and Robert F. Overmyer, pilot. They will bring the ship down at Kennedy Space Center, another first, after five days in space. This will also be the first flight of mission specialists: Dr. Joseph P. Allen and Dr. William B. Lenoir. A former experimental test pilot, Brand flew in the Apollo-Soyuz Test Project in July 1975. Overmyer is a former Marine Corps and Air Force pilot who performed engineering development duties in the Shuttle programme. A research physicist, Dr. Allen is a senior scientist astronaut. Dr. Lenoir was an assistant professor at Massachusetts Institute of Technology, researching remote sensing of planetary atmospheres and surfaces.

The sixth Shuttle flight, in January 1983, will be flown by *Challenger*. A two-day mission, it will deploy NASA's tracking and data relay satellite, part of a two-spacecraft system that will provide more comprehensive voice and data coverage for orbiting Shuttles.

Paul J. Weitz will command STS-6 with Karol J. Bobko as pilot, and Donald H. Peterson and Dr. Story Musgrave as mission specialists. Weitz was pilot for the first manned Skylab flight 25 May–22 June 1973. Bobko was a member of the Skylab medical experiments altitude test, a 56-day simulation, and chase pilot for Shuttle approach and landing tests. A former research pilot, Peterson has been serving in the Shuttle orbital flight test missions group. Dr. Musgrave is a scientist astronaut who contributed to the design and development of Shuttle extra vehicular equipment.



STS-3 emerging from the VAB before its launch on 22 March. More Shuttle news can be found in this month's "Space Report" and Leroy Day's article ("Preliminary Results from STS-3").

NASA

NASA has announced that it will no longer designate backup crews for Shuttle missions.

LAUNCH HAZARDS

Eleven months after the STS-1 launch in April 1981 NASA has acknowledged that some contractor employees suffered temporary illness from byproducts of the Solid Booster Rockets.

A local newspaper reported 13 cases but quoted "KSC officials" as saying that fewer than five were affected. The propellant in each booster weighs 503,627 kg and consists of aluminium percholorate powder (oxidizer 69.93%), aluminium powder (fuel 16%), iron oxide (a catalyst) 0.07%, a polymer (12.04%) and an epoxy curing agent (1.96%).

Inspection disclosed the launch pad to be coated with white powder varying from a quarter of an inch thick to a thin film. Analysis confirmed the dust to be mainly aluminium oxide. Dr. Paul Buchanan found a dryness of mucous membranes in the employees. "We told them to load up on orange juice and take saline nose drops," he said.

For the STS-2 launch in November cleanup crews assigned to the pad area were given plastic gloves and surgical masks. Buchanan said the pad was washed down and there was no recurrence of the irritation. Of more concern is the possibility of hydrochloric acid fallout which might be carried away from the launch base by wind. This could result in metal corrosion or chemical burns to humans and animals, Buchanan explained.

OZONE/SHUTTLE PROBLEM

Over a 10 year period Shuttle launches could deplete the ozone layer and allow up to a 2 per cent increase in ultraviolet rays reaching Earth. A 1976 study cited a possible skin cancer increase as a worst case result. Hans Rudolph, the study manager, disagreed. He said the loss of ozone would be confined to a Central Florida area and would last not more than five days. High amounts of chlorine in the exhaust of Solid Booster Rockets break down the ozone's molecular structure. That result, he added, would be restricted to a band at 28 degrees North latitude. Within five days, however, Rudolph said the "hole" caused by the Shuttle closes completely.

Dr. William Knott, KSC biological science officer, commented that "we're working on the edge of known technology. Reports of ozone depletion are based on laboratory results. It is pure conjecture." The NASA study concluded that the full impact of ozone depletion on mankind will not be known for two or three generations.

The *Today* newspaper of Cocoa in Florida, quoted a 1976 letter prepared by scientists at NASA's Ames Center stating that a Titan III rocket, using smaller boosters than the Shuttle, caused a 40 per cent loss of ozone in its ascent column. A U-2 aircraft found the ozone "hole" caused by Titan's exhaust at 11 miles altitude.

SHUTTLE REPRESENTATION

Eight companies accepted NASA's offer of access to every stage of launch processing for STS-3 at the Florida base. Each assigned managers and engineers to observe the work of civil service and contractors preparing *Columbia* for its third test mission.

The firms include United Air Lines, Rockwell, Lockheed, Martin Marietta, United Space Boosters, Grumman Aerospace, General Dynamics and Boeing. They are expected to compete for a major launch processing contract, employing more than 2,000, in 1983. Once installed, the new contractor will release approximately 500 government employees and some personnel currently employed by Shuttle contractors.

NASA has told a Senate committee that private industry has not responded to Shuttle development. Maj.-Gen. James Abrahamson, current chief of the Space Transportation System, said that more flights are needed to stimulate commercial cargo. "In order to gain the benefits inherent in the Shuttle we have to get a new cultural approach to satellites and space missions, and that's not easy," he said.

SHUTTLE COSTS

NASA has revised its Shuttle programme costs upward from the March 1972 original estimate of $5150 million to $20,084 million while pointing out the latter equates to $6748 million in 1971 dollars.

Current estimated cost for an Orbiter including engines, remote manipulator system, galley and closed circuit television is $1200 million. The agency says that equals $535 million in 1971 dollars. The original estimate for an Orbiter, $250 million, was revised to $350–$400 million based upon reducing the fleet from five to four Orbiters as ex-President Carter decided.

Columbia's thermal protection system was expected to cost $200 million, increased to $315 million currently. As for the main engines and solid rocket boosters, the costs increased as follows ($M):

	1972 estimate	*1982 estimate*
Main engine	$580	$1406
Solid boosters	390	582
External tank	399	637

NASA estimates total cost of the programme (four Orbiter fleet) for development and production ($M):

Development and Test: 10,083
Production: 7204
Fleet investment: 3794
Orbiter and KSC ground equipment: 521
Operational spares: 1513
Integration and support: 1376

Estimated costs of production hardware ($M):

Solid Boosters, per set (2): 11.3
External Tank: 10.1

Current NASA contracts for Shuttle components ($M):

Rockwell International (Orbiters): 3560
Rocketdyne (Main engines): 1546
Martin Marietta (External Tank): 529
Thiokol (Solid Boosters): 206
United Space Boosters: 89
McDonnell Douglas (Support): 52
Grumman (Wings): 45
McDonnell Douglas (OMS RCS pods): 85

Comparing Shuttle with earlier US manned programmes ($M):

Mercury: 392
Gemini: 1281
Apollo: 21,349
Skylab: 2460

STS-2 DAMAGE

While damage to *Columbia's* thermal protection system (tiles) was considerably less after STS-2 than STS-1, repairs before STS-3 added up to a fairly heavy workload. Robert Sieck, Shuttle project engineer, explained that damage resulted from launch and landing debris, moisture, an umbilical lanyard that whipped against the tiles and tyre pressure sensor wiring.

In all 3750 damaged tiles were repaired and 2500 gap fillers (inserted between tiles) reworked. Only 471 tiles required replacement: 175 due to significant damage, 202 for densification, 36 involved in experiments, 18 for engineering evaluation, 11 because they failed bond testing, 14 due to damage sustained at KSC and 15 fell into a miscellaneous category.

Concerning major flight anomalies which that during STS-2, Sieck mentioned:

1. APU 1 and 3 lubricating oil pressure high, resulting in

decision to shorten the mission. Technicians flushed oil in gear boxes and changed filters in all three APU's.

2. APU 1 low chamber pressure when started. The unit was removed and replaced. The anomaly occured because of fuel bubbles. A successful firing was conducted for STS-3 on the launch pad.

3. Fuel Cell 1 failure caused by contamination plugging the water aspirator for hydrogen pump. All three cells were removed and inspected while Cell 1 was replaced. All three were tested on the pad.

SRB MODIFICATIONS

Since the present Shuttle configuration is over weight and cannot deliver 65,000 lb to orbit in due-East launches, NASA has asked Congress to accept reprogramming of funds for lighter booster rockets. The agency wants to replace eight out of 11 metal segments of the motor case with four segments made of composite filament material. Some components (metal forward and aft domes and the External Tank attach segment) would not be changed.

Marshall Space Flight Center estimates the substitution would increase payload capacity by 6,000 lb. Air Force requirements for high performance launches into polar orbit from Vandenberg Air Force Base in California dictate the change. Lighter cases would also increase Shuttle capability when launched from Florida; first use of the new boosters would come in late 1985. Test firings will take place at Thiokol's plant near Brigham City in Utah.

SPACE STATION

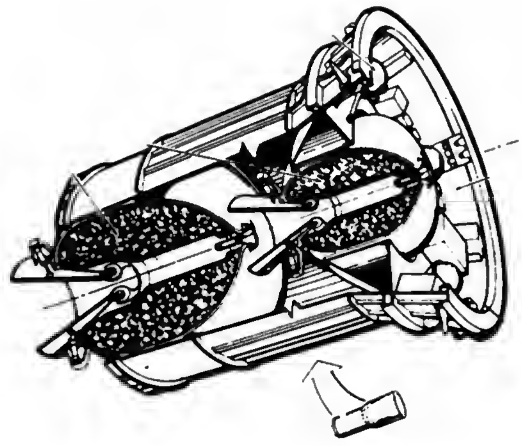
NASA Administrator James Beggs is talking of an international space station as the next major project, tying the European and Japanese Space Agencies into the US programme. All three organisations are considering the proposal, considered by some Washington observers as tacit admission that little enthusiasm has been aroused in White House or Congress for a multi-billion dollar successor to Skylab if financed entirely by American money.

INERTIAL UPPER STAGE

The Inertial Upper Stage (IUS) has beaten the Centaur for future Shuttle missions. That choice was affirmed by Air Force officials before a House of Representatives subcommittee meeting on 24 February. Under Secretary Edward Aldridge declared that the IUS "meets all the performance requirements for the Defence Department until the late 1980's." He added, "Centaur does not envelop Defence payload requirements."

The IUS-Centaur controversy has been known to Congress for more than a year. Although NASA had accepted IUS the agency changed its attitude in late 1980 because of continuing cost overruns and technical problems experienced by Boeing, the builders of IUS. Dr. Robert Frosch, then NASA administrator, proposed that General Dynamics should modify their Centaur for Shuttle applications without seeking competitive bids.

In March 1981 Dr. Alan Lovelace, a former NASA official, suggested in Congress that a "sole source procurement" was justified, otherwise a planned launch of the Galileo probe to Jupiter would be delayed by 18 to 24 months. Lovelace left NASA recently and is now a vice president of General Dynamics. James Beggs, presently NASA administrator, left his job as executive vice president of the same firm when nominated by President Reagan for the top agency position.



The IUS will make its first flight this summer on a US Air Force Titan 34D.

Last autumn, a subcommittee chaired by Rep. Ronnie Flippo told NASA and the Air Force to study their upper stage requirements, but the White House directed NASA to drop Centaur because of budget constraints.

Aldridge told the committee that to develop both would cost $1000 million; IUS has cost $595 million. "The development has been a rather turbulent one," Aldridge added, with "significant schedule extensions and major cost increases." He insisted the project was technically sound "and our performance projections indicate that IUS can meet all of our near-term needs for Earth-orbiting missions."

SPACE COURSE

The Florida Institute of Technology is offering a Master's course in space technology to be conducted at the Kennedy Space Center and Patrick Air Force Base. It is designed for younger scientists and engineers working for NASA, the Air Force and their contractors. Some instructors will be drawn from Space Shuttle teams.

PULSAR

Scientists of Marshall Space Flight Center have discovered the third fastest pulsar known. "The pulse rate of this item in the Large Magellan Cloud system is once very 69 thousandths of a second," said Dr. Martin Weisskopf. The Crab Pulsar pulses once every 33 thousandths of a second, the Binary Radio Pulsar every 55 thousandths of a second. Dr. Gerald Skinner of the University of Birmingham was involved in the research. He noted an X-ray source from HEAO-1 data and HEAO-2 revealed the pulsar.

EXPLORER DISCOVERY

New data concerning polar wind has been obtained from a retarding ion mass spectrometer flown on the Dynamic Explorer spacecraft, launched on 1 August 1981. Dr. C. R. Chappell of the Marshall Space Flight Center pointed out that the prevailing theory describes a low energy outflow from the ionosphere at high magnetic latitudes. The existence of such winds at expected velocities and at much higher velocities was confirmed by the experiment.

EXTENDED VIKING "SUCCESSFUL"

The extended mission of Vikings 1 and 2 has been declared to be a complete success. Four Viking spacecraft, two orbiters and two landers, arrived at the Red Planet in the summer of 1976, and the Viking 1 lander is still returning data. All four spacecraft returned valuable information on the meteorology and geology of Mars far longer than called for in original mission plans.

The extended mission began after the spacecraft completed their highly successful initial mission. The two landers completed a complex set of biochemical experiments aimed at determining if there was life on the planet. The results of these experiments, which included retrieving surface samples with robot arms and analysing them in microbiological laboratories, were tantalising but inconclusive. All four spacecraft provided spectacular photographs of the planet, and instruments returned a wealth of data on the atmosphere and climate of Mars.

The extended mission gathered long-term data on meteorology to assist in a study of Mars' seasons, and returned high resolution photographs to continue geological and geochemical studies.

The long-lived Lander 1 now enters a third phase of exploration, a continuous but low activity programme to return imaging, meteorology, radio science and engineering data on eight-day cycles from now until 1994.

During the extended mission, the Viking spacecraft provided nearly continuous monitoring of weather at the landing sites. While the weather in the Martian midsummer was found to be repetitious, in other seasons it was variable with cyclic variations in weather patterns.

The semi-annual variations of barometric pressures resulting from condensation and sublimation of atmospheric carbon dioxide on the polar caps was found to be unexpectedly large; the maximum and minimum mean daily pressures observed by Lander 1 were 6.8 and 9.0 millibars.

Another surprise was the generally small magnitude of wind velocities; neither lander recorded a gust in excess of 120 km (74 mi) an hour, and mean velocities were much lower. Nevertheless, the orbiter instruments observed more than a dozen small dust storms and two global dust storms. Both global storms obscured the Sun at the landers' sites for a time and hid most of the planet from the orbiter cameras.

Photographs from the landers and orbiters surpassed expectations in quantity and quality. The total number of pictures exceeded 4,500 from the landers and 51,500 from the orbiters, most of which were obtained during the extended mission. The orbiter cameras observed new and often puzzling terrain and provided clearer detail on known features, including some colour and stereo observations, and mapped about 97 percent of the surface at resolution of 300 m (1,000 ft) or better, and two percent at resolution of 25 m (82 ft) or better.

The orbiter infrared thermal mappers and atmospheric water detectors showed that the residual north polar ice cap which survives the summer is composed of water ice.

Analysis of radio signals from landers and orbiters provided a variety of valuable information about the shape and gravitational field of the planet as well as its orbital position.

Other significant discoveries from the Viking Extended Mission are:

- Changes in the Martian surface occur extremely slowly (at least at the two landing sites). Only two very small changes were observed in four years.
- The greatest concentration of water vapour in the atmosphere is near the edge of the north polar cap in midsummer and moves to the equator in the autumn, with about a 30 percent decrease in global abundance. In the southern summer, the entire planet is dry, probably also an effect of the dust storms.
- The density of both Mars' satellites is low. The surface of Phobos is marked with at least two families of parallel striations. These features are probably fractures caused by a large impact that may nearly have broken Phobos apart. Observations of Deimos showed no striations, subdued filled small craters, and car-sized blocks.
- Measurements near two solar conjunctions of the round-trip time of radio signals between Earth and the Viking spacecraft have shown delays caused by the Sun's gravitational field which confirm the prediction of Albert Einstein to an estimated accuracy of 0.1 percent, 20 times greater than any previous test.
- Mars is seismically much less active than Earth.

This scene of Mars was taken by Viking Lander 2 soon after planetfall in 1976. The horizon is some 3 km (2 mi) away. Lander 1 is still operating, with an extended mission stretching into 1994.

NASA

- The permanent north cap is water ice; the south cap probably retains some carbon dioxide throughout the summer.
- Water vapour is relatively abundant only in the far north during the summer but subsurface water in the form of permafrost covers much if not all of the planet.
- The northern and southern hemispheres are drastically different climatically because of the effect of global dust storms that originate in the south in summer.

DOUBLE LANDING ON VENUS

Russia's latest two Venus probes, Veneras 13 and 14, made successful soft-landings on the planet on March 1 and 5 respectively, writes Andrew Thomson. The probes sent back the first colour photos of the surface and performed the first onboard soil-sampling experiments.

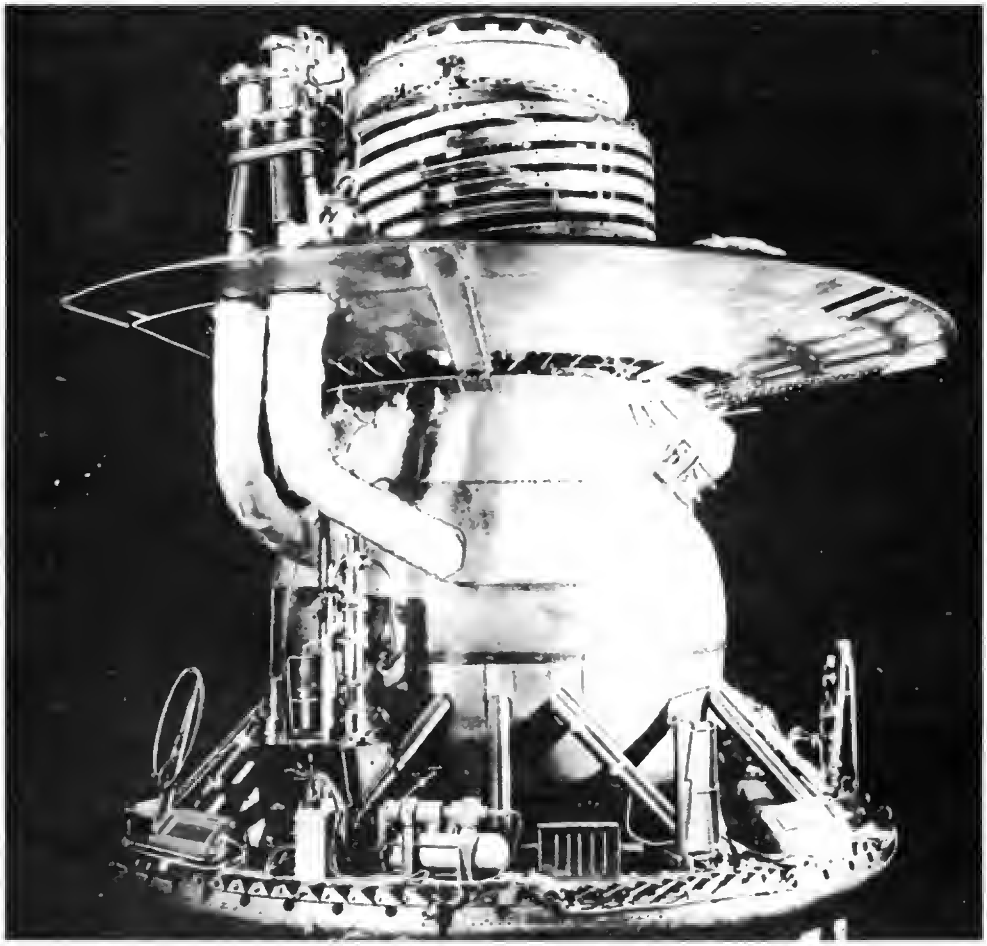
Russia's Venus programme began with a string of failures before the first soft-landing in 1970. Veneras 9 and 10 – larger, redesigned craft – radioed back the first surface photographs in 1975. Veneras 11 and 12 in 1978 soft-landed successfully, but it seems that their instruments did not function as planned – no pictures were ever released, and the whole mission was overshadowed by the highly-successful US Pioneer-Venus mission.

Venera 13 landed at 7.5° South, 303° longitude, recording temperatures of 457° C and pressure of 89 atmospheres. It operated for 177 minutes (four times the designed lifetime), returning eight panoramic photographs. Venera 14 landed at 13.25° South, 310° longitude, recording temperatures of 465° C and pressure of 94 atmospheres. It operated for 57 minutes, returning pictures which included the first colour view of the orange Venusian sky. Both craft used parachutes down to a height of 47 km, and large saucer-like rims around the top of the craft for aerodynamic braking for the remainder of the descent.

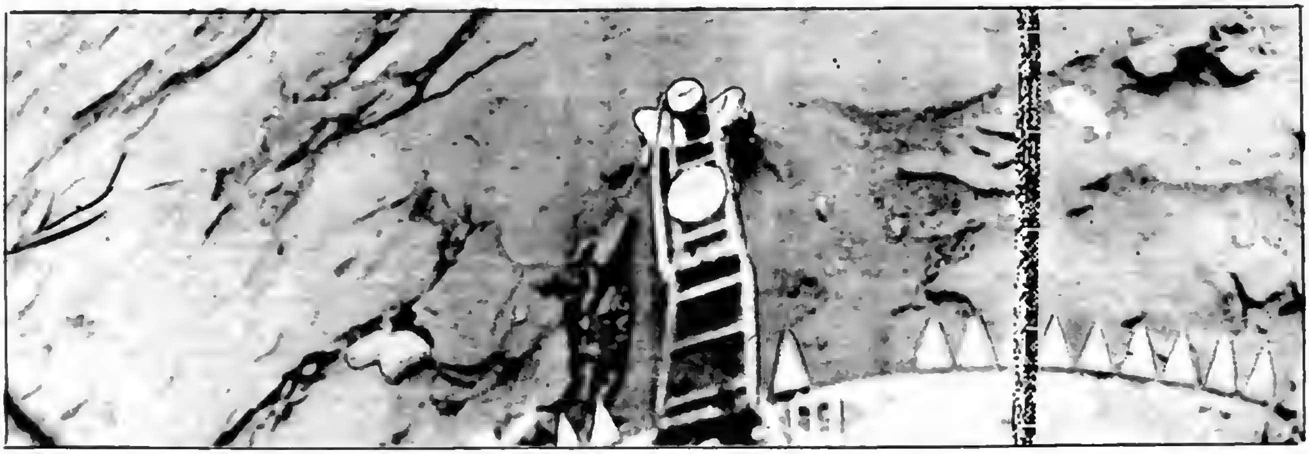
Previous Soviet probes had landed "blind" because no one knew what lay below the opaque clouds. However, for Veneras 13 and 14 the US shared Pioneer-Venus radar data with the Soviets (the first direct cooperation in planetary exploration), and the landing sites were chosen with this in mind. Venera 14 was aimed to land on a low-lying basin area and Venera 13 on rolling plains to the north-west; both sites were east of the Phoebe Regio mountainous region. The objective was to investigate two of Venus' four broad geological zones; Venera 14's basin area being lava plains, depressed regions flooded by lava flows from within the planet; Venera 13's rolling plains being possibly part of Venus' original crust (the other two zones are the Phoebe and Beta Regio mountainous volcanic regions, where Venera 9 and 10 landed, and the larger Ishtar and Aphrodite high plateaux regions, somewhat akin to Earth's continents).

Gamma ray fluorescence analysis from Venera 8 detected patterns of chemicals in the rocks similar to granites on Earth – a finding in line with Pioneer-Venus' later radar maps which revealed that Venera 8 had landed on a rolling plains region. These findings were expected to be confirmed at Venera 13's site by the much-refined soil sampling techniques on these latest probes, including for the first time screw-drills to extract samples for onboard analysis, this time by the more sensitive technique of X-Ray fluourescence.

Detailed chemical analysis data has (at the time of writing), not been revealed, but the Soviets have discussed the basic



The descent module of Venera 13. The corresponding bottom rim on the Venera 14 capsule can be seen in the Venus surface picture on the next page.



The area around the Venera 14 lander. In the centre is the spring-loaded mechanical properties sensor, while at upper right the white object is the camera cover.

Novosti

rock types from which they believe the two craft acquired data. This, and other reports, suggests that Venera 13 may have missed a "rolling plains" landing and come down like Venera 14 in a basaltic, lava region. The Soviets say that "analysis of the rock shows that 60–70 per cent of the planet's surface is covered with ancient basalt melt. It can be said today that highly alkaline potassium basalts ... are the prevalent components of rock on the surface of Venus." Such basalts occur on Earth only in deep oceanic trenches, but have been found in lunar samples. This statement is ambiguous; we do not know on what basis the statement that these rocks are the "prevalent components" of the surface of the whole planet is made. However, the suggestion of predominantly basaltic rocks indicates that Veneras 13 and 14 may have landed in very similar areas, thus making the mission only a qualified success geologically, and negating somewhat the value of the liason with US scientists over site selection.

However, the data are not yet all in, and the question-marks over the sites in geological terms do not lessen the feat of another successful double-landing, operation of instruments on Venus' surface for two hours, colour pictures of the surface, and the first onboard soil sampling of a planet whose surface temperatures are nearly five times the boiling point of water on Earth.

SPACE TELESCOPE

Bradford Smith, of the newly founded Space Telescope Institute, said just before the launch of STS-3 "We are hoping that it (Space Telescope) will go up in early 1985, if it is on schedule." He went on to describe his expectations for the data produced by the Space Telescope, writes Gerald Borrowman. "Well, for an example, we can look out and see part of our own Solar System to the planets that have not yet been visited by spacecraft, like Uranus, Neptune and Pluto. In fact, the Uranus observations will be important for Voyager as we are going to arrive at Uranus with that spacecraft in early 1986."

MYSTERY CLOUD

NASA researchers with the help of laser probing data have taken the mystery out of the "mystery cloud" that covered the Earth's northern hemisphere for several weeks this year.

Ruling out the possibility of an undetected nuclear detonation or a meteor impact, Dr. M. Patrick McCormick of NASA's Langley Research Center said the cloud is actually a layer of particulates that appear identical to data Langley researchers are accustomed to seeing from volcanic eruptions.

The fact that no major eruptions have been reported recently does not dissuade McCormick from his view: "It had to be one that had little local damage but moved material high enough to get into the stratosphere where it can travel around the world. Historically, information on the height of volcanic eruptions has proven unreliable due to, among other things, the difficulty of accurately observing them at night or through cloud cover."

McCormick, head of the Aerosol Measurements Research Branch at Langley, said the eruption probably occurred in late December 1981 or during the first two weeks of January 1982. The results were first observed by the Japanese on 23 January and then by another ground-based station in Moana Loa, Hawaii on the 28th.

Not until 13 and 14 February, when a NASA research airplane flew from Wallops Flight Center on Virginia's Eastern Shore to Costa Rica in Central America, did the evidence begin to overwhelmingly point to a volcanic eruption as the source of the high-altitude pollution.

The altitude and intensity of the cloud, by then a diffused layer, was detected continuously from Wallops, at 38 degrees north latitude, to Costa Rica, at 10 degrees north latitude.

A remote-sensing laser radar, looking upward from the plane, mapped the otherwise invisible layer as being approximately 16 km (10 m) high at the middle and an average of 3.2 to 4.8 km (2 to 3 m) thick.

Comparisons with volcanic emission data taken from 1979 to 1981 by a NASA satellite instrument called SAGE (Stratospheric Aerosol and Gas Experiment) convinced Langley researchers that they were seeing the same pattern of particulate distribution. Furthermore, the closest match was with known volcanic eruptions that were about two months old, closely correlating to the suspected beginnings of the present emission.

The airplane instrument recorded peak concentration at about 20 degrees north latitude, close to the latitude of Hawaii. This indicates to McCormick that the emission was probably a low-latitude eruption, perhaps between the equator and 20 degrees north, as atmospheric travel tends to be away from the equator.

A nuclear or meteoric source for the material is ruled out by McCormick for several reasons: "Our laser radar data show the new aerosol (particulates) are equivalent to about a quarter of a million tons or more of new material in the stratosphere. A nuclear explosion would not have produced that much mass.

TETHERED SATELLITES

NASA's Marshall Space Flight Center has issued a two-part "request for proposal" to Ball Aerospace Systems Division of Boulder in Colorado and Martin Marietta Aerospace of Denver for the purpose of conducting detailed engineering analyses and selected advanced development evaluations of a Tethered Satellite System concept. Both companies, as a result of prior competitive procurement, were selected to conduct parallel definition studies of the system which they recently completed.

Candidate for development leading to launch in the late 1980's, the system would be carried into orbit by the Space Shuttle. A sub-satellite would be suspended from the cargo bay on a tether up to 50 miles long, to troll the Earth's upper atmosphere for magnetospheric, atmospheric and gravitational data. The satellite could also be deployed upward to study electrodynamic and other phenomena.

Currently there are limited means by which the upper atmosphere - around 60 to 90 miles up - can be studied. The area is too high for aircraft to reach and too low for satellites to remain in orbit for long. A number of instrument-laden rockets have been used with some limited success, but these pass through the upper atmosphere for only a few minutes before falling back to Earth. The Tethered Satellite System, however, could study the upper atmosphere for days at a time.

The first part of the request for proposal invites Ball and Martin Marietta to describe how they would do an Advanced Development Phase, which entails more detailed engineering analyses and advanced development testing of the system, plus testing of some key components similar to those to be flown in space. The second part asks the companies how they would then carry out the Design and Development Phase, which is full-scale development of the system. Sometimes called a "new start," this final phase has not yet been approved. It will not proceed unless NASA Headquarters, the Office of Management and Budget and the Congress approve it through the usual new start process, and the Marshall Center subsequently exercises the government's option to go forward with development. NASA would then share development of the system in a joint venture with the government of Italy. NASA would build the deployment system (the reel and related apparatus that would fit in the Shuttle Orbiter's cargo bay) and the Italian government would build the satellite itself. NASA would also handle the systems integration.

The request for proposal closed on 17 May. The Marshall Center then began to evaluate the proposals submitted by the companies. It plans to award a contract for the Advanced Development Phase by this October, with a firm option for the Design and Development Phase.

The US/Italian agreement for the current study phase evolved from an initiative in 1980 by the Italian government's PSN/CNR (Italian National Space Plan/National Research Council) to NASA for possible collaboration on the Tethered Satellite System which the US space agency had been studying since the mid-1970's. In 1981 a Letter of Agreement was signed by NASA and PSN/CNR which established the tasks each agency agreed to undertake during the study phase. The agreement also provided for a science working group, co-chaired by NASA and PSN/CNR, to provide science requirements and to develop and recommend the scientific objectives of the Tethered Satellite System. A subsequent agreement between NASA and the Italian government would provide for actual cooperative development of the TSS.

ANCIENT EARTH IMPACTS

Scientists have uncovered evidence that huge meteorites may have given birth to the Earth's continents, writes Gerald L. Borrowman.

"We've uncovered patterns in gravity density which lead us to believe that North America was formed after a giant meteorite crashed into what is now central Canada, said Klaus Jurgen Schultz, a fellow of the McDonnell Center for Space Sciences at Washington University in St. Louis.

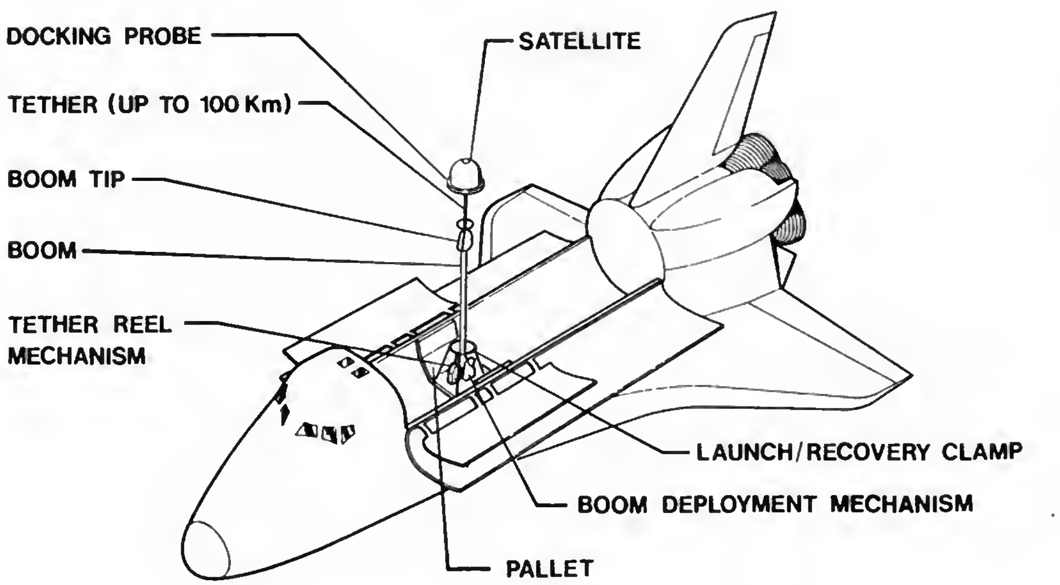
"North America should not be unique," Schultz said, "so we're now trying to find gravity data for other continents of comparable quality to what we have for North America."

Cravity data on this continent has long been available, Schultz said, but until recently no one had looked at it on a large scale.

What such a study revealed to Schultz, John Klasner, a geophysicist at Western Illinois University, and William Cannon, a geologist with the US Ceological Survey, was a huge bull's-eye ripple effect with the centre in the middle of Canada.

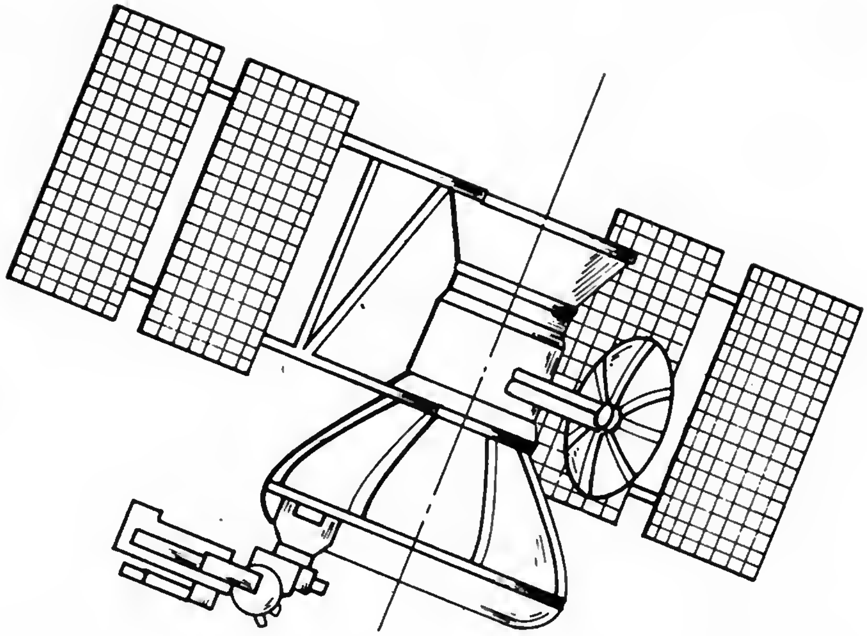
Schultz, who interpreted the data, said that it showed underground impact rings stretching for 1,700 miles from what is now Hudson Bay in the north to below the present location of the Great Lakes in the south.

The scientists pointed out that the Moon and other planets in our Solar System show that large bodies pelted them early



The Shuttle tethered satellite system is being studied by Ball Aerospace and Martin Marietta.

British Aerospace



Soviet Venus/Halley probe of 1984 after separation of the Venus landing capsule. Two spacecraft will be launched in December 1984, with arrival at Venus in the summer of 1985. See news story below.
ESA

in their lives and there is no reason to believe the Earth escaped unscathed.

The difference, Schultz said, is that planets such as our Moon were cold, while the Earth had a thin crust covering molten stone and metal.

Schultz's impact theory holds that the body that struck Canada was some 60 to 90 miles in diameter. It set off a chain of volcanic eruptions lasting millions of years and produced the granitic rock that would become the North American continent.

The theory itself is not new, but what has been lacking was physical evidence to support it.

Scientists believe the Earth to be 4,600 million years old whereas the oldest rocks date back only some 3,800 million years, leaving an 800 million-year gap that has remained a mystery.

VENUS/HALLEY 1984

An ESA conference of scientists and engineers involved in studying the return of Halley's Comet to the inner Solar System in 1986 has provided details of the two Soviet Venera-Halley probes.

The Soviet mission to the comet is a combined Venus swingby/Halley fly-by mission. Two identical spacecraft will be launched during the period of 22-28 December 1984 and after carrying Venus entry probes to the vicinity of Venus (with the arrival and deployment of the probes between 14-22 June 1985), the two spacecraft will be re-targeted using Venus' gravitational field to intercept Halley's Comet in March 1986. The first spacecraft will encounter the comet on 8 March 1986, and the second about a week later. Fly-by velocity will be about 77 kms/second, at distances of around 10,000 km for the first spacecraft and 3,000 km for the second.

The Venera-Halley spacecraft is described as being three-axis stabilised. Its main features are large solar panels, a high-gain antenna dish, and an automatic pointing platform carrying those experiments that require pointing at the comet nucleus. This platform carries the narrow and the wide-angle camera, a three-channel spectrometer and the infrared sounder. All other experiments are body mounted, with the exception of two magnetometer sensors and various plasma probes and plasma wave analysers which are mounted on a 5 m boom. The total scientific payload will weigh 125 kg.

Comet-encounter data will be taken from 2½ hours before closest approach until half an hour after, with several periods of data take before and thereafter, each lasting about two hours.

The spacecraft is shielded from high dust impacts by a shield consisting of a 100 micron multilayer sheet 20-30 cm from the spacecraft, and a 1 mm aluminium sheet 5-10 cm from the spacecraft.

Details were also given at the conference of Japan's Planet-A probe to Halley. This will be Japan's first interplanetary mission, with launch from the Kagoshima Space Centre on 14 August 1985 by a three-stage Mu-3U rocket. To inject Planet-A on an encounter trajectory a fourth-stage kick motor with about 400 kg of propellant will be added. Direct injection without a parking orbit is to be employed. Since the injection error will be unknown until after launch, and the orbit-control capabilities of the on-board attitude and velocity control system are limited, Planet A cannot be precisely aimed at the comet nucleus. It is estimated that fly-by distance will be between 10,000 and 100,000 km. A test spacecraft, tentatively designated MS-T5, will be launched six months before Planet-A to prove the capability of the launch vehicle.

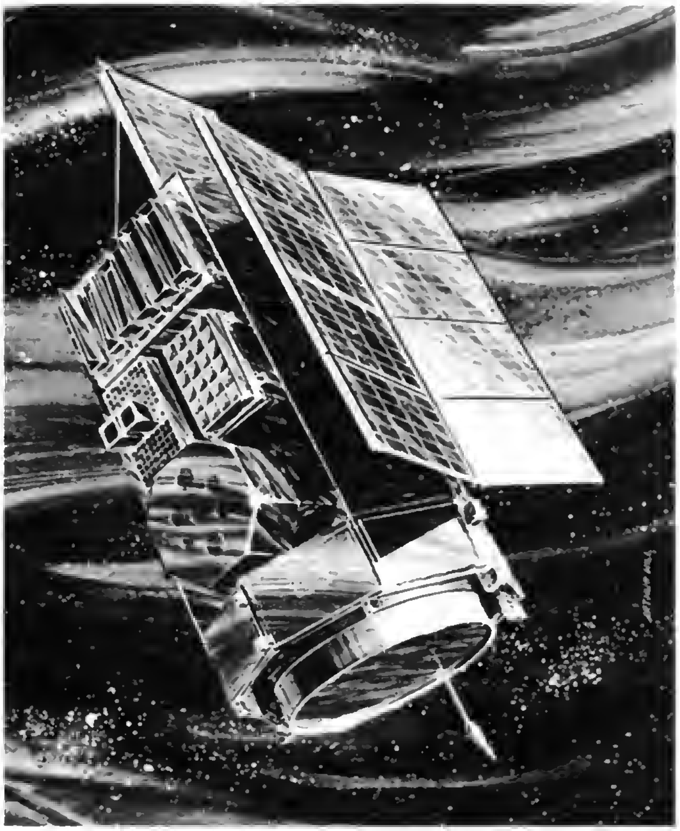
At the time of Planet-A's encounter with Halley on 8 March 1986 MS-T5 will be about 0.1 AU away.

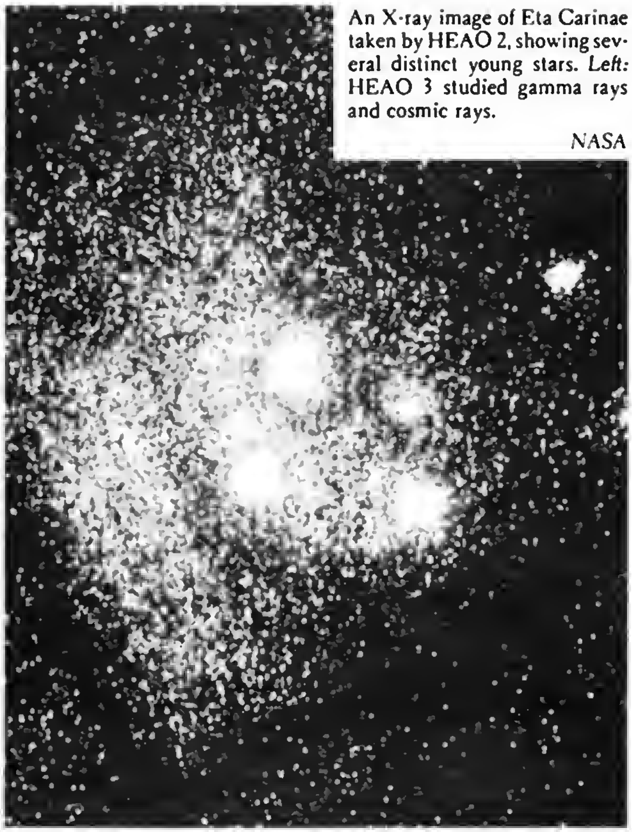
HEAO 2 RE-ENTERS

HEAO 2, NASA's second in a series of three High Energy Astronomy Observatories launched into space in the late 1970s, decayed from orbit on 25 March and burned up in the atmosphere.

"Tracking stations indicate that it broke up over the South Pacific just east of Australia," said John Stone, HEAO project manager at the Marshall Space Flight Center.

The entire family of HEAO satellites, designed to study high energy radiation as X-rays and cosmic rays, had returned significant data over a period of several years. The first observ-





An X-ray image of Eta Carinae taken by HEAO 2, showing several distinct young stars. *Left:* HEAO 3 studied gamma rays and cosmic rays.

NASA

atory, HEAO 1, re-entered the atmosphere in 1979. The third spacecraft experienced a similar fate last December. Until now, only HEAO 2 had remained in orbit, although it had not been operational for nearly a year. In April 1981, the observatory expended its control gas supply and could no longer maintain its pointing attitude, and the spacecraft was powered down.

All three of the Observatories have been described by NASA officials as "highly successful". HEAO 1, launched in August 1977, scanned the heavens in a general survey and mapped X-ray sources throughout the celestial sphere. The initial survey was completed in February 1978, the design lifetime of the satellite, but it continued to study the skies until its control gas was exhausted in January 1979. During that 17 month survey, HEAO 1 increased the number of known celestial X-ray sources from 350 to 1500. It discovered a new black hole candidate and indicated the possible existence of a universal hot plasma which would constitute a major fraction of the mass of the universe.

HEAO 1 also discovered a superhot halo of gas, 1200 light-years in diameter, surrounding the celestial Northern Cross. The halo, or "superbubble," is about 6000 light-years from Earth in the next spiral arm of our galaxy. Its discovery has formed the basis of a new theory of star formation.

The second high energy observatory, HEAO 2, focussed upon specific observations partially guided by the general celestial survey of its predecessor. Nicknamed the "Einstein observatory" by astronomers because its launch date fell almost on that of the late scientist's 100th birthday anniversary, HEAO 2 was rocketed into orbit in November 1978. Although it was designed for a mission life of 12 months, it operated for nearly two and a half years.

Carrying the largest X-ray telescope ever built and a variety of sensitive astronomy instruments, HEAO 2 conducted the detailed imaging and spectroscopic observations of approximately 300 known bright X-ray sources and discovered thousands of new faint X-ray sources. Almost every type of star in the galaxy was shown to have an X-ray-emitting atmosphere. HEAO 2 obtained the first X-ray photographs of supernova remnants, pulsars, star clusters, galactic diffuse X-ray sources, bright sources in other galaxies, and of diffuse emission from clusters of galaxies. Hundreds of active galaxies and quasars were detected, some of which may be the most distant objects ever observed at any wavelength. The Einstein observations have already had a significant impact upon most fields of astronomy.

The final observatory in the HEAO series was launched in September 1979. Unlike its predecessors, which were designed to study X-rays, HEAO 3 furthered our knowledge about cosmic-ray particles and gamma-ray photons, the two highest energy radiations in the Universe. Through the study of cosmic rays, which are the nuclei of elements and are the highest energy particles known, HEAO 3 measured the relative abundance of elements in the Galaxy. The observatory found significant differences between the abundances of certain nuclei in the galaxy and the abundance of these same elements in the Solar System.

Gamma-rays, higher on the energy spectrum than X-rays, are emitted from Galactic sources which may be unobservable to conventional telescopes. HEAO 3 detectors achieved precise, high-resolution measurements of gamma-ray "line emission" from solar flares and from positive and negative electrons combining near the galactic centre. The data from HEAO 3 are expected to further the understanding of the strength and extent of interstellar magnetic fields, the distribution of interstellar matter, and – most importantly – the stellar nucleosynthesis process which has created the heavy elements contained in most ordinary matter. According to theory, the "big bang" formed hydrogen and helium and led to star formation. All heavier elements are produced in normal and explosive stellar processes.

Although the HEAO series has already expanded Man's knowledge of the Universe, scientists say that they will require years to complete their analysis of the massive amount of data returned from the three observatories.

PIONEER'S 10 YEAR VOYAGE

Pioneer 10, the first spacecraft to reach Jupiter, completed 10 years in space on 2 March 1982.

Since launch in 1972, the spacecraft has traversed the asteroid belt, survived Jupiter's punishing radiation belts and operated almost without flaw. It has travelled in excess of 6,600 million km, received more than 40,000 commands from Earth, and returned more than 125 billion bits of scientific data.

Pioneer continues to function well and is currently engaged in a new enterprise, defining the extent and behaviour of the Sun's atmosphere, the magnetic bubble which contains the Sun and the planets. This "bubble" in the interstellar medium is called the heliosphere.

Pioneer 10 now is more than half way between the orbits of Uranus and Neptune, 4,600 million km from the Sun.

About a year from now, in April 1983, Pioneer will be farther from the Sun than the planet Pluto. By June 1983, it will be farther out than Neptune - outside all of the planets of the Solar System (in their current positions).

Pluto's orbit is so elongated that the "outermost planet" will be inside Neptune's orbit for the next 17 years. NASA officials have therefore selected October 1986 (when Pioneer crosses the mean orbit of Pluto) as the official date for the spacecraft leaving the Solar System. Pioneer will cross the farthest extension of Pluto's orbit in April 1989.

At Pioneer's current distance it takes three hours and 42 minutes for spacecraft data, travelling at the speed of light, to reach the Pioneer Operations Center at NASA's Ames Research Center in California. This one-way communication time currently is lengthening at a rate of one minute every four days.

Despite damage from intense Jovian radiation and impacts by tiny micrometeoroids, plus 10 years of continuous operation, almost all of the systems are performing well. Pioneer's magnetometer ceased to function in 1975, but experimenters can calculate the interplanetary field from charged particle trajectories, magnetic data already gathered and several correlations from five other Pioneer scientific instruments.

Scientists await current spacecraft findings "with intense excitement," says Dr. James A. Van Allen, University of Iowa, Pioneer 10 experimenter, "because we think the Sun is typical of a majority of the stars in the Universe. It's the only star we can measure from 'close up'. Finding the extent and exact mechanisms of the Sun's atmosphere will tell us a great deal about the Sun itself, about the interstellar gas surrounding the Solar System, and hence about stars in general."

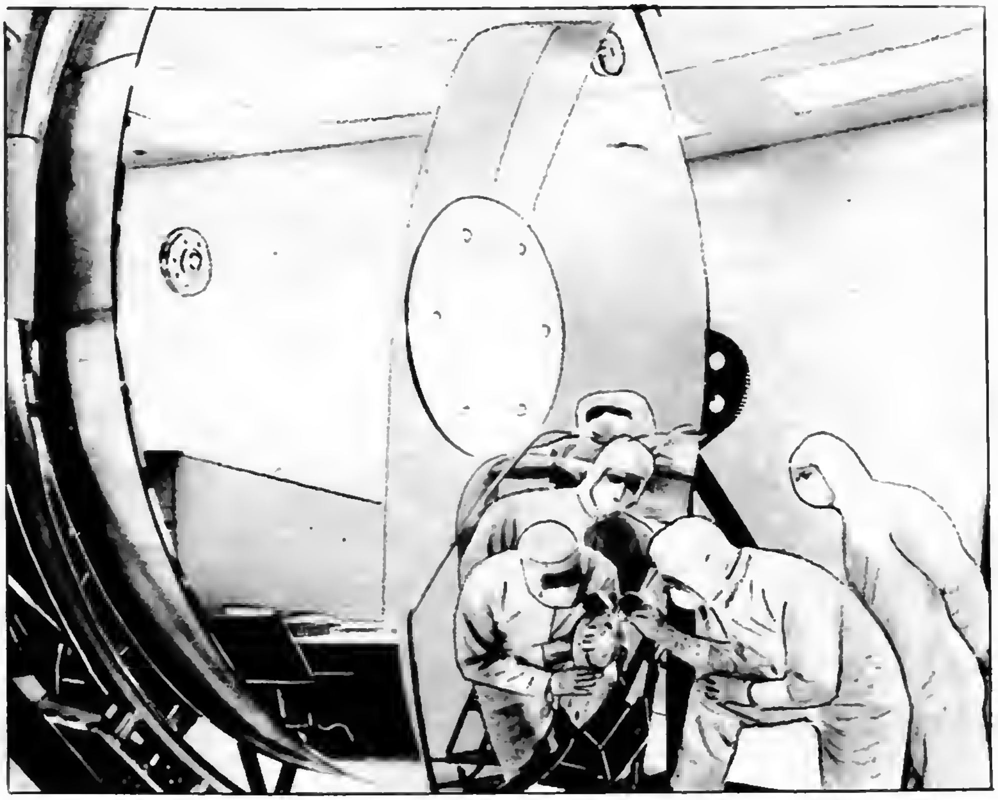
The picture now emerging seems to show that the heliosphere is enormous, far larger than predicted. The heliosphere (created by the million-mile-an-hour solar wind, blowing out from the Sun in all directions) appears to be a tear-shaped magnetic bubble. The bubble is "streamlined" by the motion of the Solar System through the interstellar gas.

Pioneer is travelling "down the tail" of the heliosphere tear drop. The spacecraft is seeking the "skin" of this heliospheric bubble, the boundary between the Sun's atmosphere and true interstellar space. No one knows, but scientists think this boundary region may lie between 5,000 million and 10,000 million miles from the Sun.

Experts at NASA's Deep Space Network expect to be able to track Pioneer out to somewhere beyond 9,250 million km.

At the long-lived spacecraft's current distance, the Earth would be seen as a pin-point of light, never more than 2.2 degrees away from a Sun still intensely bright, but no larger than a pin head. Because of this huge distance, and the decline in brightness of the Sun, Pioneer's Sun sensor will not be able much longer to provide the Sun pulse, which gives the rotational position of the spinning spacecraft several times a minute. However, NASA-Ames mission controllers have devised, and will soon be using, a method of making star maps with the Pioneer camera (imaging photo-polarimeter) to provide the needed rotational and attitude data.

Recent Pioneer discoveries about space at the edge of the Solar System raise other new questions. We now believe the heliosphere bubble "breathes" in and out once every 11-year solar cycle, according to Dr. John Simpson, University of



The 94 inch, 1800 lb mirror for the Space Telescope is ready for installation in the telescope structure. Its launch and observations of the outer planets in 1985 will allow controllers at the Jet Propulsion Laboratory in California to plan Voyager 2's encounter with Uranus in January 1986 with confidence.
NASA

Chicago, Pioneer experimenter.

The shock waves of the enormous storms on the Sun seem to persist in the heliosphere for as long as a year, probably changing the heliosphere bubble's shape, as if it were a huge pulsating jelly fish.

"It's hard to overstate the interest of the physics coming out of this phase of the Pioneer mission," comments Dr. Aaron Barnes, NASA-Ames astrophysicist. "We are constantly entering unexplored territory, and we really don't know what we'll learn about our local star."

NASA announced in early April that Sally Ride, one of the Group 8 astronauts, will fly as a mission specialist aboard STS-7 in April 1983. She will be the first woman since Valentina Tereshkova in 1963 to go into space. This mission, the second for *Challenger*, will deploy Palapa and Telesat communications satellites and the German SPAS scientific payload. Guion Bluford will be the first black US astronaut.

Three further crews have been announced. STS-7: Robert Crippen (Commander); Frederick Hauck (Pilot); Sally Ride and John Fabian (Mission Specialists). STS-8: Dick Truly (Cdr); Daniel Brandenstein (Plt); Dale Gardner and Guion Bluford (MS). STS-9: John Young (Cdr); Brewster Shaw (Plt); Owen Garriott and Robert Parker (MS). Two Payload Specialists will be chosen for this Spacelab mission later. Bob Crippen will thus become the first astronaut to fly the Shuttle into space twice (STS-1 and STS-7).

SPACE EXPLORATION SUPPORT

The Reagan administration will continue planetary space exploration and begin major new programmes despite rumours that it would axe deep space missions to save money, the presidential science advisor Dr. George A. Keyworth recently stated, writes Gerald L. Borrowman.

Dr. Keyworth said the administration would support scaled-down, unmanned missions to other planets and the start of the Gamma Ray Observatory project.

Keyworth told a meeting of the American Association for the Advancement of Science that the administration has begun a major reassessment of the space programme. But looking for cheaper, more effective ways to explore space should not be construed as lack of support or commitment, he said.

"The Reagan administration is supporting a strong initiative in planetary science, and this includes a number of new projects that will develop using the capabilities of the Space Shuttle," he said.

Keyworth offered few details on the new projects, pending completion of the programme review and completion of the Fiscal Year 1983 budget. He did indicate, however, that they may not begin until the end of the decade.

The physicist said he hoped to end some inaccurate speculation on the administration's intentions in space. There is no truth, he claimed, to rumours that the administration is considering shutting off the two Voyager spacecraft, now on their ways to Uranus and deep space, after successful missions to Jupiter and Saturn.

"The Deep Space Network is needed to receive data from Voyager will still receive support for data reception and analysis," he said. "We'd throw away billions (of dollars) for want of a few million by not funding such activities."

Keyworth said the administration will propose simplified missions to the planets that would cost a few hundred million dollars instead of $1,000 million projects such as Voyager and Viking Mars.

THE LAUNCH OF STS–3

The public and press are kept informed of what is going on during a Shuttle launch by NASA's public affairs department. Here is an edited transcript of the announcements made at the launch site as *Columbia* climbed into space for the third time:

T-5 minutes 30 seconds and counting. The development flight instrumentation recorders are on. The DFI provides measurements of temperatures, pressures and physical stresses on the Orbiter and the recorders store this information for playback after landing. T-5 minutes 12 seconds and counting. The Orbiter flight recorders are on.

The Auxiliary Power Units start up:

The APU's provide hydraulic power to move the aerosurfaces and main engines for steering. T-4 minutes 42 seconds and counting. The firing circuits for the Solid Rocket Boosters' ignition and range safety destruct devices have been armed. This is done with a motor-driven switch called a safe and arm device. T-4 minutes 20 seconds and counting. The main fuel valve heaters have been turned off in preparation for engine start. The main engines of the Orbiter will actually be started at T-6.8 seconds and it takes 3 seconds for them to reach 90 per cent thrust, at which time the solid motor ignition starts culminating with ignition and liftoff at T-0. T-3 minutes 55 seconds and counting. The final helium purge of the Orbiter's main engine has started to ensure that there's no surplus hydrogen or oxygen in the area at the time of ignition. T-3 minutes 40 seconds and counting. The elevon, speedbrake, and rudder are being moved through a preprogrammed pattern to ensure that they are ready to be used during the flight.

T-3 minutes 28 seconds and counting. The Shuttle is now on internal power. However, the fuel cells are still receiving their fuels from the ground support equipment for about another minute. T-3 minutes 12 seconds and counting. The profile checks of the aerosurfaces are now complete and the engine gimbal or movement check of the main engines on the Orbiter is underway to ensure that they are ready for flight control. T-3 minutes and counting. T-2 minutes 55 seconds. The liquid oxygen valve for filling the External Tank is closed and pressurization has begun. After the tank is pressurized, the hold capability is limited to 3 minutes and 36 seconds. T-2 minutes 40 seconds and counting. The gaseous oxygen vent arm is being retracted.

T-2 minutes 30 seconds and counting. The fuel cells' ground supply of oxygen and hydrogen has been terminated and the vehicle is now using its onboard supply. T-2 minutes 15 seconds. The main engines have been moved to start position. The astronauts have cleared the caution and warning memories in their onboard computers and verified there are no unexpected errors. T-2 minutes and counting. The astronauts are configuring the APU's, the auxilliary power units, for a liftoff. The liquid hydrogen dump valve has been closed and pressurization underway. T-1 minute 45 seconds and counting. The computers are automatically verifying the readiness of the main engines at the T-1 minute point.

T-1 minute 30 seconds and counting. T-1 minute 20 seconds and counting. T-1 minute 15 seconds. The liquid hydrogen tank is at flight pressure. Coming up on the one minute point in our countdown. One minute prior to the liftoff of the third Space Shuttle mission. T-1 minute and counting. The firing system for the sound suppression water system on the pad is armed.

T-50 seconds and counting. T-45. We are 14 seconds away from switching command of the countdown from the ground computers to onboard computers. The development flight instrumentation recorders are on. T-33 seconds and counting. The GOX [gaseous oxygen] vent arm is fully retracted and we're switching controller to countdown to the onboard computers. T-25 seconds. The sequencer on the Orbiter is now controlling the final seconds. T-20 seconds. T-15, 14, 13, 12, 10, we are go for main engine ignition, 8, 7, 6, we have main engine ignition.

The Shuttle lifts off and the tower is cleared. One of the astronauts comments on the blue sky. Manœuvres begin:

26 seconds. Roll manœuvre completed. 30 seconds. 1 nautical mile in altitude, throttling engines down now to 68 per cent as programmed. 38 seconds. Plot board status looks good Mission Control. 42 seconds. *Columbia* now 3 nautical miles in altitude. 46 seconds. Coming up now on maximum aerodynamic pressure on the vehicle. 55 seconds past through max still looking good. Throttling engines back to a 100 per cent giving a go at throttle up.

Mark 1 minute 10 seconds, *Columbia* now 7 nautical miles in altitude, 4 nautical miles down range, velocity now reading 2700 feet per second. Mark 1 minute 25 seconds. *Columbia* now 11 nautical miles in altitude 8 nautical miles down range.

The Commander warns of a cooling caution light, and SRB separation nears:

That was Jack Lousma reporting a freon loop light. 1 minute 40 seconds. Coming up on negative seats for altitude is too high for ejection seat use. Mark 1 minute 55 seconds. *Columbia* now 21 nautical miles in altitude 19 nautical miles down range. 2 minutes 2 seconds standing by for Solid Rocket Booster separation confirmation. 2 minute 15 seconds confirm Solid Rock Boosters separation.

2 minutes 23 seconds onboard guidance is converging as programmed. *Columbia* is now steering for a precise window in space for main engine cutoff. 2 minutes 30 seconds standing by for 2 engine TAL capability.

2 minutes 45 seconds. CAPCOM Terry Hart says that *Columbia* now has a two engine auto landing capability. At Rota Naval Air Station, Spain. *Columbia* now 42 nautical miles in altitude, 58 nautical miles downrange.

3 minutes 30 seconds, *Columbia* now 51 nautical miles in altitude. Return status check in Mission Control by flight director Tom Holloway. 3 minutes 40 seconds. Lousma, Fullerton given a go to continue. Mark 3 minutes 45 seconds. *Columbia* now 53 nautical miles in altitude 104 nautical miles downrange. Really moving out now, the velocity reading now 7800 feet per second.

The astronauts are told they are "negative return":

Four minutes 12 seconds; with that call up Lousma and Fullerton committed to space travel; they can no longer turn around and return to the launch site. Four minutes 20 seconds.

The first indication of APU trouble comes in:

Four minutes 28 seconds, that was a report of an APU temp light, four minutes 33 seconds *Columbia* now 60 nautical miles.

Five minutes 22 seconds. The PRESS to MECO call from CAPCOM Hart. Should *Columbia* loose about one engine, press on keep flying forward, *Columbia*'s engines have enough energy to achieve normal altitude and velocity at cut off. Five minutes 35 seconds. *Columbia* now 63 nautical miles in altitude, 255 nautical miles downrange. Velocity now reading 12,300 feet per second.

APU 3 continues to give problems, and the Orbiter can land in Spain even if two main engines failed:

Six minutes 5 seconds, that report from CAPCOM Hart indicates if a two engine failure occurred, Lousma and Fullerton are capable of an emergency landing at ROTA Naval Air Station, Spain.

That was Commander Jack Lousma reporting another message on APU 3. Six minutes 45 seconds, *Columbia* now 62 nautical miles in altitude, 398 nautical miles downrange.

Mark, seven minutes, *Columbia* pitching over now, diving to decrease or increase their velocity, decrease altitude giving *Columbia* more favourable altitude. Seven minutes 10 seconds, standing by now for single engine PRESS to MECO call up by CAPCOM Terry Hart. Seven minutes 25 seconds, *Columbia* now 69 nautical miles in altitude, 545 nautical miles downrange.

The crew are advised to close down APU3:

That was CAPCOM Terry Hart telling the crew to shutdown APU 3. The single engine PRESS to MECO call says that the crew can achieve normal engine cut off targets even if two engines go out. Eight minutes four seconds, *Columbia* now 59 nautical miles in altitude, 630 nautical miles downrange. G forces building for Lousma and Fullerton, coming up to 3 G's. Eight minutes 18 seconds, *Columbia* three main engines slowly being throttled back now, should be throttled at 68 per cent at six seconds before main engine cutoff. Mark eight minutes 30 seconds standing, by now for main engine cutoff.

The main engines cut off and the External Tank separates:

Eight minutes 46 seconds, confirmed shutdown, *Columbia* again returned to space, not yet returned to orbit, standing by now for External Tank sep.

Confirmed External Tank separation. Nine minutes two seconds, *Columbia* now performing an evasive manœuvre moving below and beyond the External Tank. Nine minutes 14

UK STS-3 EXPERIMENT

Included among the scientific payload carried aboard STS-3 was one designed and built at the University of Kent at Canterbury, the first non-US experiment to be carried in the Shuttle. Known as the microabrasion foil experiment (MFE) it tested a new method of analysing micrometeorites and cosmic dust (including material from comets) to improve our understanding of the history and development of the Solar System.

Current modelling of early Solar System processes is based primarily on the laboratory analysis of relatively large meteorites recovered on Earth. Such analysis will always be deficient in studies of low density cometary material, since meteorites made of such material will almost never survive a journey through the Earth's atmosphere. The MFE provides a novel technique for collecting this material.

The experiment, mounted in the centre of the Spacelab pallet, consisted of a number of aluminium foil sheets bonded to a plastic (Kapton) substrate. During the flight the sheets were exposed to space. Very light particles will not have penetrated the foil but will have formed a hyper-velocity impact crater on the foil surface; heavier particles will not have fragmented and should have survived intact, yielding valuable data as to their density and on which scientists may be able to explain the origin of the particles.

The experiment is funded through Science and Engineering Research Council's Astronomy, Space and Radio Board and is the first of a number of different experiments currently being developed in UK universities for later flights of the Shuttle. The Kent group is also preparing further hardware for a later Shuttle flight (late 1983) when a similar package will be placed into orbit for exposure to space over a far longer duration and recovered on a later mission.

seconds; go, no-go status check on Mission Control by Flight Director Tom Holloway for the first OMS burn [to achieve initial orbit].

9 minutes 38 seconds, given a go for OMS-1 and the APU shutdown on time. 9 minutes 50 seconds. *Columbia* now manœuvring to OMS-1 burn attitude using the two 6,000 pound thrust engines. OMS-1 will be positive grade moving *Columbia* forward and higher on her flight path, placing *Columbia* into a limited life time orbit. Report *Columbia* now at burn attitude. In burn attitude. 10 minutes 43 seconds the prop systems controller reports ignition two good engines. *Columbia* doing the first OMS burn now.

This is Shuttle Control, Houston. 12 minutes Mission Elapsed Time. Prop reports cut off on the first OMS burn. We have loss of signal now with *Columbia* through Bermuda. The next station to acquire will be Madrid. 12 minutes 25 seconds. We expect Madrid acquisition at about 6 and a half minutes. This is Shuttle Control Houston. 15 minutes 24 seconds Mission Elapsed Time. Flight Dynamics Officer Ron Epps reports the following results for the first OMS burn. Time of ignition 10 minutes 33 seconds Mission Elapsed Time. Delta V 153 feet per second. Burn duration 1 minute 27 seconds. Resulting apogee of 130 nautical miles. Resulting perigee 46 nautical miles. At 15 minutes 58 seconds Mission Elapsed Time this is Shuttle Control Houston.

The second OMS burn raised perigee height to 130 km. Columbia *was in orbit!*

NEW SHUTTLE TILES

New developments at NASA's Ames Research Center are changing the face of the Space Shuttle's thermal protection system.

Second generation materials – lighter, stronger and more cost-effective than the original components – have been developed by Ames and will be installed in stages on four shuttle orbiters over the next few years.

Some new materials have already been installed on *Columbia*. Others are planned for *Challenger*, due for delivery this summer, and for *Discovery* and *Atlantis*, scheduled for delivery in 1983 and 1984.

The thermal protection system consists of tiles and other refractory materials applied to the outer shell of the Orbiter to protect its aluminium and graphite-epoxy skin from extreme temperatures. Temperatures on a flight may range from −110°C (−170°F) in space to nearly 1648°C (3000°F) during reentry.

Changes in the system reflect NASA's growing understanding of the problems of reentry. Although the original materials performed well beyond expectations, research continues to produce more sophisticated materials, according to Howard Coldstein, head of the Ames Thermal Protection Materials Section.

Columbia has had a silica glass quilt, known as Advanced Flexible Reusable Surface Insulation (AFRSI), installed over 20 sq. ft. of its elevon cove, replacing the Felt Reusable Surface Insulation (FRSI) which originally covered the area. FRSI had to be replaced because temperatures in the elevon cove area reached 816°C (1500°F), whereas the FRSI was designed for areas no hotter than 398°C (750°F). Plans originally called for AFRSI installation in some areas on the next orbiter, *Challenger*, but the overheating brought a decision to add the new materials for the second flight of *Columbia*.

AFRSI is tougher, lighter and cheaper than earlier tile heat shields. It was conceived by Ames and produced by Manville Building Materials Corp., Denver, Colo. A square foot of AFRSI costs about $200, compared to about $1000 a square foot for tile materials.

On *Challenger*, AFRSI will be installed on the Orbital Maneuvering System (OMS) pods and will partially replace Low Temperature Reusable Surface Insulation (LRSI) tiles developed and manufactured by Lockheed.

On *Discovery* and *Atlantis*, AFRSI will replace all of the LRSI and parts of the FRSI, covering more than 2,700 sq. ft. Also on these future Orbiters, another new material called Fibrous Refractory Composite Insulation (FRCI-12, because of its 12 lb per cubic foot density) will replace LI-2200 tiles. Both of these materials were developed by Ames and are manufactured by Lockheed.

The new FRCI-12 is lighter and stronger than LI-2200 and will save about 1,000 lb on *Discovery* and *Atlantis*. LRSI and HRSI tiles presently come in two densities: the LI-2200, 22 lb per cubic foot, and LI-900, nine lb per cubic foot.

HRSI is covered with the black, reaction-cured borosilicate glass coating developed by Ames to protect the high temperature areas, about 43 percent of the total surface of the Orbiter. The white, borosilicate-coated LRSI tiles are located primarily on the upper surfaces.

Another Ames development used in the thermal protection system is the filler that fills nearly 5,000 gaps between tiles, where it prevents hot gas from reaching the aluminium skin.

OOPS!

When a preserved V-2 missile was recently transferred by road from the Cranfield Institute of Technology to the London Science Museum's airfield site at Wroughton, near Swindon, the driver of the lorry got more than he bargained for. He parked his load en route in Stony Stratford where anti-nuclear demonstrators mistook it for an American cruise missile; they made it quite clear that he and his deadly cargo had to leave town!

IN THE PAST

25 Years Ago . . .
24 June 1957. Malcolm Ross and Charles Moore reach an altitude of 40,000 ft as part of the Stratolab series of flights.
7 August 1957. A Jupiter-C launcher flies to a peak altitude of 600 mi in a test of ablative reentry materials.

20 Years Ago . . .
16 June 1962. NASA announces that tests of the Apollo Service Module propulsion system will be conducted at the White Sands Missile Range in New Mexico.
21 July 1962. NASA announces that a new launch complex for the Apollo/Saturn programme will be built. Known as Complex 39 it will include three launch pads.

15 Years Ago . . .
28 June 1967. The Apollo 4 spacecraft, due for launch aboard the first Saturn 5, completes a systems test in the VAB.
1 August 1967. Launch of Lunar Orbiter 5 to complete the lunar-mapping series of spacecraft.

10 Years Ago . . .
10 July 1972. The 500th satellite of the Cosmos series is launched. The series began in March 1962.
26 July 1972. NASA selects North American Rockwell to build the Space Shuttle Orbiter.

5 Years Ago . . .
16 June 1977. Wernher von Braun dies at the age of 65.
12 August 1977. Shuttle Orbiter *Enterprise* makes the first in a series of free flights. Astronauts Haise and Fullerton land the craft after a glide lasting 5½ minutes.

D. J. SHAYLER

SATELLITE DIGEST - 156

Robert D. Christy
Continued from the June issue

A monthly listing of satellite and spacecraft launches, compiled from open sources.

The heading to each launch gives the name of the satellite, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes except where marked with an asterisk, where the time is to the nearest minute as announced by the launching agency

UPDATES:

The following satellites have decayed:

Desig.	Name	Date	Lifetime (d)
1978-41A	HCMM	1981 Dec 22	1336
1979-65A	Cosmos 1114	1981 Dec 26	899
1979-82A	HEAO 3	1981 Dec 7	809
1979-100A	Cosmos 1146	1981 Nov 25	721

LAUNCH FAILURE:

An attempt by the United States to launch a NAVSTAR navigation satellite from Vandenberg on 18 Dec 1981 failed due to a malfunction in the launch vehicle.

COSMOS 1338 1982-11A, 13061

Launched: 1110, 16 Feb 1982 from Plesetsk by A-2.
Spacecraft data: Possibly based on Vostok manned spacecraft with spherical re-entry module, instrument unit and cylindrical, supplementary payload at the forward end. Length about 6 m, max diameter about 2.4 m and mass around 6000 kg.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: Initialy 200×362 km, 90.18 min, 72.89 degrees; manoeuvred to 357×414 km, 92.29 min, 72.86 degrees after one day.

COSMOS 1339 1982-12A, 13065

Launched: 2203, 17 Feb 1982 from Plesetsk by C-1.
Spacecraft data: Cylindrical body with domed ends, enclosed in drum shaped solar array, with length and diameter both around 2 m. The mass may be around 700 kg.
Mission: Navigation satellite replacing or backing up Cosmos 1092 (1979-30A).
Orbit: 954×1016 km, 104.85 min, 82.91 degrees.

COSMOS 1340 1982-13A, 13067

Launched: 0142, 19 Feb 1982 from Plesetsk by A-1.
Spacecraft data: Possibly based on the Meteor satellites with a cylindrical body and two, Sun-seeking solar panels. Length about 5 m, diameter about 1.5 m and mass around 2000 kg.
Mission: Possibly electronic reconnaissance. Normally, satellites of this type fly in one of six orbit planes separated by 60 degrees longitude at the equator. This particular vehicle's orbit plane is 12.5 degrees to the east of that of Cosmos 1206 (1980-69..).

WESTAR 4 1982-14A, 13069

Launched: 0010, 26 Feb 1982 from the Eastern Space and Missile Centre, Cape Canaveral Air Force Station by Delta 3910.
Spacecraft data: Cylindrical structure covered in solar cells, 2.16 m diameter and 2.74 m high in the stowed position. An extending, cylindrical solar panel which was deployed after launch increased the length to 6.84 m. The satellite is based on the Hughes Aircraft Company's standard HS 376 vehicle. The last launch of the type was SBS 2 (1981-96A). Westar 4 is spin stabilised with a de-spun antenna array, a technique pioneered by Hughes. The mass is 585 kg.
Mission: Commercial communications for the Western Union Telegraph Company, providing 24 transponder channels.
Orbit: Placed into a geostationary transfer orbit by the launch vehicle, an onboard apogee boost motor was used to alter this to an equatorial drift orbit. Stabilised above 79 degrees west for systems checks, the final location is to be 99 degrees west when in operation.

MOLNIYA-1(53) 1982-15A, 13070

Launched: 2010, 26 Feb 1982 from Plesetsk by A-2-e.
Spacecraft data: A cylindrical body housing instrumentation and the payload, surmounted by a conical motor section. Power is provided by a "windmill" of six solar panels. Overall length is 3.6 m, diameter 1.6 m and mass around 1800 kg.
Mission: Replacement or backup for Molniya-1(47), 1980-53A. The satellite helps to operate long distance telephone and telegraph communications, and the broadcasting of Central television programmes to Orbita receiving stations in the Soviet far north, Siberia, the Soviet far east and central Asia.
Orbit: Initially a low parking orbit and then injected into a highly elliptical one of 476×40747 km, 735.46 min, 62.85 degrees. On the 11th orbit this was lowered to 474×39892 km, 718.01 min, 62.87 degrees in order to ensure daily repeats of the ground track.

COSMOS 1341 1982-16A, 13080

Launched: 0546, 3 March 1982 from Plesetsk by A-2-e.
Spacecraft data: Possibly based on the Molniya design (see previous entry) with length about 4 m and mass around 2000 kg.
Mission: Probably part of the USSR's system of missile early warning satellites, replacing or backing up Cosmos 1247 (1981-16A).
Orbit: Initially a low parking orbit and then injected into an elliptical one of 625×39252 km, 708.11 min, 62.89 degrees. Later manoeuvred to 630×39684 km, 716.95 min, 62.91 degrees to ensure daily ground track repeats.

INTELSAT 5(F4) 1982-17A, 13083

Launched: 0110, 5 Mar 1982 from Launch complex 36, Eastern Space and Missile Centre, Cape Canaveral Air Force Station by Atlas Centaur.
Spacecraft data: Three axis stabilised, box shaped vehicle with a 16 m span solar array. A more detailed description can be found in the entry for INTELSAT 5(F3) - 1981-119A in the May 1982 *Satellite Digest*.
Mission: Provision of telephone and television communications for the International Telecommunications Satellite Organisation.
Orbit: Initially a geostationary transfer orbit before circularisation at the seventh apogee on 7 Mar. After testing, full operation was due during May 1982 from location 63 degrees east.

SOCIETY NEWS

PROGRESS IN THE LIBRARY

Identifying, locating and acquiring missing items, some examples of which are listed in the Desirada accompanying of this report, is going to be a long haul. This slowand somewhat painstaking rate of progress over the past few months is borne outby our curren stock position, which reads as follows:

	As at 9.3.82	As at 31.10.81
Books	1993	1921
Reports	3932	3816
	5925	5737

This increase is considerably less than before but, if the basis of about 50 accessions per month can be maintained, it would average an increase in value of our Library stock at about £5-6,000 p.a.

This is not to say that members have ceased to offer material. Far from it. A quick run-down of some of the first over the past few months alone more than bears this out. Sam Dauncey, complaining that his own bookcases were overflowing, deposited some useful items with us, while Prof. Gerry Groves added some excellent ESA Reports to his earlier gifts. Steve Fawkes, among the Scottish mists, managed to unearth an excellent book on Space Law which we hadn't previously seen. D. H. Martin, from the Aerospacc Corporattion, sent us a copy of "Communication Satellites 1958-1982" - which we liked so much that we had the cheek to ask him for a second copy!

Stateswise, Capt. Bob Freitag produced some fine NASA Reports, Geoffrey Beauchamp provided several bound volumes of the AIAA *Journal, Astronautics* and *Astronautics Sciences Review* and Don Larson waded in with an almost complete set of copies of *Space World*.

Two extremely interesting batches of books arrived in March. One was a selection of publications on large space telescopes from the European Southern Observatory, the other a selection from the World Data Centre at Goddard Space Flight Center though, unfortunately, some were in microfiche form, which reduces access somewhat.

Responding to our appeal to authors to present copies of their works, Desmond King-Hele came up with an outsize tome, recently published by Macmillan, called "The RAE Satellite Tables 1957-1980." Bob Powers also waded in with a copy of his new book, "The Coattails of God".

A particularly helpful offer came from Neil Hilton, who not only scoured a local secondhand bookshop to list all of the astronomical and space books in its shelves, but coupled this with an offer to buy and donate any we wished for. Unfortunately, the list didn't included any we required but the measure of goodwill was greatly appreciated.

Some members appear to be particularly adept at obtainig books for us from other sources. One such example was an excellent book on the Sun, collected by Lawrence Dargavel from a Library which was about to throw it away.

The Library Committee continued to write to members who have lately retired, to ask if they were willing to present some of their material to the Society. We are hoping that the response from this source will prove of great value in future years. We had the opportunity of going through the papers of Dennis Carton, a late member of the Council, from which we were able to extract a number of documents of interest.

Both Ron Lewis and Dr. Les Shepherd responded to the appeal in a previous Library report for missing issues of *Spaceflight* and *JBIS* to help complete our sets. To both we express our most grateful thanks. Unfortunately, we have have not yet been able to plug every gap so our need is still great.

This handsome display cabinet is a recent addition to our Library.

We are anxious to get, particularly, extra copies of the *JBIS* issues for January, February and March 1980.

Historical

Unfortunately, our piggy-bank was short by about £3,000 to buy the copy of Bayer's *Urania* printed in 1603. This copy, we hasten to add, was not the one stolen from University College Library a short while earlier. Its pedigree was even more doubtful; it was, so we saw an antique imported *from* America!

To compensate, Rex Turner produced a very early ESRO Report on space stations, a copy of which we had long wanted but which been unobtainable for many years. Dr. Roth-Oberth was also more than kind in presenting two books containing biographies of Professor Hermann Oberth, both of which we were delighted to receive.

Display Material

Joel Powell provided a sample of the Odessa (Texas USA) meteorite which fell approximately concurrently with the Meteor Crate event - say in the last 100,000 years. Unfortunately, we haven't been able to agree on the actual year of discovery but it was cetainly in the 1920's. The crater was 168 m in diameter and 18 m deep (a fossil horse helped to establish its age).

The Odessa crater, which has been obliterated by car drivers, was the second impact crater identified on Earth, apparently by Barringer himself (1926). An intriguing theory is that the Odessa and Barringer (Meteor Crater, Arizona) objects were one body that split up during entry, and produced two impacts! It is known that their ages are concurrent and the fragments similar.

Deane Davis also turned up trumps with a number of mementoes including an Atlas lighter, as well as a collection of launch badges.

First-Day Covers

Chris Allen provided three Skylab first-day covers, Douglas Arnold produced another, Richard Greaves provided a selection on Woomera launches, while Rex Hall continued to help us build up a fine collection of Soviet Space stamps.

Obtaining first-day covers may not be without its problems. Len Carter, on his way out from the Cape Canaveral Post Office on such a mission, was stopped at the door and asked if he wanted work. A house-painting job was going! Does that explain why our Apollo first-day covers are in such short supply? Did any other members atempting to post their first-day covers end up with D.I.Y. jobs?

Slides and Tapes

The proposed collection of tape recordings got off to a good start with a collection of Apollo sets provided by Douglas Arnold. Several other members provided recordings, including Rex Turner, Adrian Perkins and Max Wholey so we have, certainly, made a modest start. Mel Smith, a member of the Library Committee, tailed things off nicely with a collections of slides.

Early Astronomical Instruments

The Library Committee is currently mulling over the idea of collecting a representative selection of early astronomical instruments for display; including such items as early star maps, celestial globes, orreries, telescopes and similar items.

Their chances of doing this unaided are probably not too bright at present, but they are hoping that other members will like the idea and help them find suitable items. Should anyone have or come across anything of this nature, please contact Len Carter at once.

DESIRADA

Here is a list of books and other items which we would like to have to plug gaps in our collection. If any members have, or discover copies of any of these in second-hand bookshops, which they would like to present to us, we would be more than happy to hear from them.

Since this is the first time that the Library Committee has specifically indicated books which we would like to receive, they plan to monitor the response with considerable interest.

Astronautics

—	Rendezvous in Space: The Story of Projects Mercury, Cemimi, DynaSoar, and Apollo	Dutton, 1962
—	Vanguard! The Story of the First Man-Made Satellite	Dutton, 1957
E. W. Downs, ed.	The U.S. Air Force in Space	Praeger, 1966
K. F. Cantz, ed.	Men in Space: The United States Air Force Program for Developing the Spacecraft Crew	Duell, 1959
T. J. Gordon & J. Scheer	First Into Outer Space	St. Martin, 1959
J. J. Haggerty	First of the Spacemen	Duell, 1960
R. Hirsch and J. J. Trento	The National Aeronautics and Space Administration	Praeger, 1973
P. J. Klass	Secret Sentries in Space	
R. S. Lewis	The Voyages of Apollo: The Exploration of the Moon	Quadrangle, 1974
M. M. Link	Space Medicine in Project Mercury	
A. McIntyre	Summary of AFCRL Rocket and Satellite Experiments (1946-1966)	AF Cambridge Research Laboratories 1966
—	Space Handbook. Maxwell Air Force Base	Air University Revised, annually

Missiles

E. Abel	The Missile Crisis	Lippincott, 1966
M. H. Armacost	The Politics of Weapons Innovation: The Thor-Jupiter Controversy	Columbia University, 1969
J. Baar & W. E. Howard	Combat Missilemen	Harcourt, 1961
E. Beard	Developing the ICBM: A Study in Bureaucratic Politics	Columbia University, 1976
E. Bergaust	Rockets of the Armed Forces	Putnam, 1966
E. M. Bottome	The Missile Cap	Fairleigh Dickinson University, 1971
N. J. Bowman	The Handbook of Rockets and Cuided Missiles	Perastadion Press, 1963
R. W. Buchheim	Space Handbook: Astronautics and Its Applications	Random, 1959
B. Collier	The Battle of the V-Weapons	Morrow, 1965
W. Dornberger	V-2: The Nazi Rocket Weapon	Viking, 1954
—	Nuclear Flight: The United States Air Force Programs for Atomic Jets, Missiles and Rockets	Duell, 1960
—	The United States Air Force Report on the Ballistic Missile: Its Technology, Logistics, and Strategy	Duell, 1960
C. Curney, ed.	Rocket and Missile Technology	Watts, 1964
M. Hunter	The Missilemen	Doubleday, 1960
C. C. Lasby	Project Paperclip: Cerman Scientists and the Cold War	Atheneum, 1971
J. McCovern	Crossbow and Overcast	Morrow, 1964
J. B. Medaris and A. Cordon	Countdown for Decision	Putnam, 1960
R. Neal	Ace in the Hole: The Story of the Minuteman Missile	Doubleday, 1962
S. Ulanoff	Illustrated Cuide to U.S. Missiles & Rockets	Doubleday, 1962
USAF Missile Develop. Center	History of Research in Space Biology and Biodynamics	Holloman AFB, 1959

Astronomy

C. F. Chambers	The Story of Comets	Clarendon Press, 1909
J. F. Coodavage	The Comet Kohoutek	Pinnacle Books, 1973
W. Ley	Visitors from Afar – The Comet	McGraw Hill, 1969
A. L. Lowell	Biography of Percival Lowell	Macmillan Co., 1935
J. Mascart	Le Comete de Halley	Cauthier-Villars, 1911
C. P. Olivier	Comets	Williams & Wilkins, 1930
N. B. Richter	The Nature of Comets	Methuen, 1963

Magazines

*AAS Science and Technology Series – Vol 38.
*AAS Advances in Astronautical Sciences – Vols. 7 and 31.
British Astronomical Association Journal – Vols. 1-34.
British Astronomical Association Memoirs – Vols. 22, 25, 28, 31, 33 and 40.
International Astronautical Federation Proceedings: 6th (1955), 21st-26th (1970-1975), 29th (1978).

**A set of practically all of the volumes in these two series has been presented to us by the American Astronautical Society, whose generosity in this is gratefully appreciated.*

If any reader has these books which he is willing to donate to us to complete our set, do please send them to us.

37th ANNUAL GENERAL MEETING

NOTICE IS HEREBY GIVEN that the 37th ANNUAL GENERAL MEETING of the BRITISH INTERPLANETARY SOCIETY Limited will be held in the Kent Room, Caxton Hall, Caxton Street, London SW1 on Saturday, 25th September 1982 at 3 p.m. precisely.

AGENDA

1. To receive the Report of the Council on the Society's Affairs for the year to 31st December 1981.
2. To receive the Society's Balance Sheet and Accounts for the year ended 31st December 1981 and the Auditors' report thereon.
3. To appoint Auditors and determine the method of fixing their remuneration. The present auditors have expressed their interest in continuing in Office.
4. To elect four Members of the Council of the Society. In accordance with article 15 the following Members of the Council will retire at the meeting:

   P. J. Conchie — L. R. Shepherd
   K. W. Gatland — G. M. Webb

If the number of nominations exceeds the number of vacancies, election will be by postal ballot in accordance with Article 44. The final date for the receipt of ballot papers will be 31st January 1983.

5. General Discussion.
6. Closing Remarks by President.

By Order of the Council
L. J. CARTER,
Executive Secretary.

A member who cannot be personally present at the meeting may appoint by proxy some other person, who must be a member of the Society, to attend and vote on his behalf, subject, however, to the proviso that a proxy cannot vote except on a poll.

BRITISH INTERPLANETARY SOCIETY LIMITED (BY GUARANTEE)

REPORT OF THE AUDITORS

We have audited the financial statements set out on pages 2 to 6* in accordance with approved Auditing Standards.

In our opinion the financial statements which have been prepared under the historical cost convention, give a true and fair view of the state of affairs of the Society at 31st December, 1981 and of the surplus for the year ended on that date and comply with the Companies Acts 1948 to 1981 insofar as the provisions of those Acts apply to these financial statements.

The financial statements do not specify the manner in which the operations of the Society have been financed or in which its financial resources have been used during the year as required by Statement of Standard Accounting Practice No. 10.

FRASER KEEN
Chartered Accountants

4 London Wall Buildings,
London EC2M 5NT.

* *Refers to original document*

Balance Sheet as at 31st December 1981

1980 £		Notes	£	£
115,271	*FIXED ASSETS*	2		102,211
17,087	Staff Pension Fund Investments at Cost	4		28,077
	CURRENT ASSETS			
—	V.A.T. Recoverable		726	
25,000	Bank: Deposit Account		25,792	
115	Cash in Hand		—	26,518
157,473				156,806
	LESS: CURRENT LIABILITIES			
—	Sundry Creditors		110	
4,397	London Borough of Lambeth		3,198	
26,500	Bank Overdraft	3	16,574	19,882
£126,576	*NET ASSETS*			£136,924
	Represented by:			
	ACCUMULATED FUND			
125,278	Balance at 1.1.1981			126,576
1,298	Excess of Income over Expenditure for year			10,348
£126,576				£136,924

NOTE: For the treatment of subscriptions in advance see note 3.

Income and Expenditure account for the year ended 31st December 1981

1980 £		£	£
	INCOME		
56,049	Subscriptions from Members	75,101	
31,791	Sales of Publications	34,554	
6,096	Income from Investments	11,038	
795	Sundry Receipts	1,041	
94,731			121,734
	Less: EXPENSES		
	Office and Administration		
20,721	Salaries and National Insurance	29,575	
7,466	Rent, Rates, Light, Heat, Cleaning, Insurance and Repairs	8,855	
250	Audit and Accountancy	300	
4,637	Postage, Stationery and Telephone	4,281	
150	Sundry Expenses	120	
	Depreciation:		
2,814	Buildings	2,856	
1,254	Fixtures and Fittings	2,093	
	Member Services		
55,139	Publication of Magazines	60,618	
500	Meetings Expenses	1,014	
502	I.A.F. Contribution and Expenses	494	
—	Library Expenses	1,180	
93,433			111,386
£1,298	Excess of Income over Expenditure		£10,348

Notes to and forming part of the accounts
for the year ended 31st December 1981

1. *ACCOUNTING POLICIES*

(a) *Depreciation:* Depreciation has been provided at rates which are considered appropriate in reducing the cost of the assets to their residual value over their estimated useful life. The rates used are:
Freehold Buildings-2% on a straight line basis
Fixtures and Fittings-10% on a straight line basis

(b) *Stocks:* No account is taken of any publication or sundry stocks which are treated as being written off in the year of purchase.

2. *FIXED ASSETS*

	Freehold Land £	Freehold Buildings £	Fixtures and Fittings £	Library £	Total £
Cost					
Balance at 1.1.1981	33,963	140,690	12,539	11,467	198,659
Additions during year	—	2,115	8,389	—	10,504
Balance at 31.12.1981	£33,963	£142,805	£20,928	£11,467	£209,163
Depreciation					
Depreciation at 1.1.1981	—	5,628	4,517	—	10,145
Charge for year	—	2,856	2,093	—	4,949
Balance at 31.12.1981	—	£8,484	£6,610	—	£15,094
Balance at 31.12.1981	33,963	134,321	14,318	11,467	194,069
Less:					
Contributions received to date	33,963	32,110	14,318	11,467	91,858
N.B.V. at 31.12.1981	—	£102,211	—	—	£102,211

3. *BANK OVERDRAFT*

During the latter part of 1981 £52,716 (1980-£54,794) being subscriptions relating to the following year were received and utilized to clear the bank overdraft. This amount is not reflected in these accounts because your Council are of the opinion that inclusion would show a misleading view of the financial affairs of the Society.

4. *STAFF PENSION FUND INVESTMENTS*

1980 £		No. of Units	Cost £
3,465	Income Units	12,278	4,088
158	Financial Security	266	162
3,464	High Yield	10,155	3,827
7,087			8,077
10,000	Special Deposit Account		20,000
£17,087			£28,077

The market value of the quoted investments at 31.12.1981 was £11,096 (1980-£9,676).

BENEVOLENT FUND

FOR THE YEAR ENDED 31st DECEMBER 1981

	1981 £	*1980* £
Appeal Account		
Balance at 1.1.1981	8,838	7,607
Interest and Dividends (Gross)	1,066	1,231
	£9,904	£8,838
Investments		
2,539 Save and Prosper High Yield Units	954	863
2,943 Save and Prosper Group Unit	962	864
Bank Deposit	7,988	7,111
	£9,904	£8,838

The market value of the quoted investments at 31.12.1981 was £2,649 (1980 - £2,362).

1981 CALENDAR OF EVENTS

GENERAL MEETINGS AND LECTURES

7 Jan	Lecture: "Space Museums" by Dr. F. J. Becklake.
4 Feb	Lecture: "Developments in Civil Satellite Communication" by J. Adams and P. Moss.
25 Feb	Lecture: "Role of a Principal Scientific Investigator in Space Projects" by Dr. G. E. Hunt.
11 Mar	Film Show: "Europe in Space".
18 Mar	Visit to the Royal Aircraft Establishment, Farnborough, Hants.
26 Mar	Lecture: "Aspects of Rocket Propulsion" by M. R. Fry.
8 Apr	Lecture: "The Infrared Astronomical Satellite (IRAS)" by Dr. R. Holdaway.
29 Apr	Lecture: "The Philately of the Soviet Space Programme" by Rex D. Hall.
6 May	One-day discussion: "Daedalus in Retrospect".
20 May	Film Show: "The Making of an Astronaut (Part 1)".
27 May	Lecture: "Planet 10 - The Gift from Galileo" by A. T. Lawton.
3 Jun	Lecture: "Spacelab" by Dr. M. J. Rycroft.
2 Sep	Lecture: "The Ariel 5 & 6 Experience" by Dr. M. J. Ricketts.
14 Oct	Lecture: "Recent Advances in Space Flight" by P. S. Clark.
17 Nov	Discussion: "The Solar Sail Race".
18 Nov	Lecture: "Observations of the Atmosphere of Venus from the Pioneer Orbiter" by Dr. F. W. Taylor.
2 Dec	Film Show: "The Making of an Astronaut (Part 2)".

TECHNICAL SYMPOSIA AND CONFERENCES

23 Jan	Technical Forum: "Military Satellite Programmes".
15 Apr	Symposium: "Space Transportation Systems for the 1990s".
29/30 May	Symposium: "The Soviet Space Programme".
6-12 Sep	32nd IAF Congress, Rome, Italy.

STUDY COURSES 1981

Theme: "Rocket Technology"

14 Jan	"Electric Propulsion" by D. G. Fearn.
11 Feb	"Advanced Propulsion - What Future for the Rocket?" by Dr. R. C. Parkinson.
4 Mar	"Sizing of Multi-Stage Rockets" by Prof. I. E. Smith.

Theme: "Remote Sensing"

30 Sep	"What is Remote Sensing?" by Dr. J. R. Hardy.
28 Oct	"Platform Sensors and Data Processing" by Dr. J. R. Hardy.
11 Nov	"Data Classification and Interpretation" by Dr. J. R. Hardy.
25 Nov	"Space Oceanography" by Dr. J. O. Thomas.
9 Dec	Visit to the Laboratory for Planetary Atmospheres, University College, with Dr. G. E. Hunt.

BUSINESS MEETING

26 Sep	36th Annual General Meeting.

OTHER EVENTS

12 Jly-2 Aug	Solar Eclipse viewing trip arranged by the Southern California Branch.
7 Oct	"First Night" - Social Evening at H.Q.

REPORT OF THE COUNCIL

FOR THE YEAR ENDED 31 DECEMBER 1981

Introduction

The year under review has been one of spectacular progress with significant innovations in our main operations of publications and meetings and much preliminary work has been done on events to commemorate the Society's completion of its first half-century of existence.

Meetings

A full programme of meetings and events was held in our Conference Room at the Society's Headquarters. The lectures and symposia covered most aspects of astronautics and are detailed in the adjoining 1981 Calendar of Events. The winter months are a convenient time for holding Study Courses which survey specific topics in some detail and are intended for the serious student. They have proved popular over the years and 1981 saw the concluding meetings of the Study Course on Rocket Technology and the opening lectures of the Course on Remote Sensing.

For the second year running we held a "First Night," an informal social evening which enabled new members to meet the Council, Officers, and Staff of the Society and to become acquainted with some of the history of the Society and the facilities provided at our Headquarters. This event was much appreciated by the members who participated – one came from as far afield as Hawaii.

The work of the Space Technology Committee deserves particular mention. The basis of all advances into interplanetary space depends on a sound space transportation system so the Committee has, wisely, concentrated on this task. Their Symposia on the subject have done much to ensure that we are continually made aware of every development in this most important area. However, this has not been the only topic. Discussions have ranged far afield and included many matters of potential interest, from the use of solar sails to manned exploration of other worlds. Most of this material will continue to find its way into the pages of the Society's magazines.

A good deal of work was done on Space '82, an event which will be held next year to herald entering our 50th Anniversary Year. Members will have already seen some of the preliminary advertising and can judge that this will be a really outstanding event. Those from the provinces and overseas who may not have been to a Society meeting before are urged to attend and will be particularly welcomed by Members of the Council, our Committees and Staff, all of whom will be there in force.

International Affairs

A delegation from the BIS attended the IAF Congress held in Rome on 6-12 September 1981. As a founder member of the International Astronautical Federation (IAF) the BIS plays an important part in its work and contributes towards its operating expenses.

Publications

The Council and its Publications Committee are continually reviewing the possibilities for extending the range of our publications in any form likely to be economically viable and which would attract an adequate supply of suitable contributions. The first two issues of *Space Education* were published in 1981 and distributed as a supplement to *Spaceflight*. In this way *Space Education* could be introduced to all current subscribers, including many libraries as well as BIS members. It is hoped that the popularity and sales of the new magazine will continue to grow and that it will soon be possible to establish it as a

fully independent publication. In addition to *Space Education*, the Society continued to publish *JBIS* and *Spaceflight*. During the course of 1981 the Editor of *Spaceflight*, Mr. K. W. Gatland resigned this position as he was taking up a post in the aerospace industry. Ken Gatland had edited our popular magazine for over two decades. We thank him for his long and dedicated service to the Society and wish him well in his new employment. In 1981 Mr. Andrew Wilson joined the BIS Staff on a full-time basis and fulfils the role of Managing Editor of *Spaceflight*.

The new Honorary Editor of *Spaceflight* is Prof. Groves, a former Editor of the Journal. Mr. A. D. Farmer is Editor of *Space Education* and, as in recent years, we have a team of specialist editors for *JBIS*, each issue being handled by the relevant Editor.

It is astonishing to reflect that we have to encompass all the work of getting out one complete issue, from beginning to end, in just 11 working days! Our magazines consume an enormous amount of material so we are always interested in seeking out new articles and features. In 1981 our space news coverage was bigger and better, and included a fair amount on Society news, done with flair and a very friendly touch.

The Society's books "Project Daedalus" and "High Road to the Moon" continued to sell well, the former now in a second print issue. A further volume in this series with the provisional title of "The Eagle has Wings", is now in course of preparation.

Membership

The following table compares the Society's memberships at 31 December 1980 and 1981:

Grade	*31.12.81*	*31.12.80*
Fellows	947	732
Associate Fellows	760	783
Members	1,392	1,593
TOTAL	3,099	3,108

The position is by no means as static as these figures might suggest so we constantly welcome the influx of new members. There is also a steady stream of members transferring to higher grades as their qualifications and/or level of experience improves.

BIS Development Appeal

We are deeply grateful to the many members and friends who have contributed to our Stage 2 Appeal. Their donations have enabled us to make a substantial repayment of part of the loan relating to our Headquarters building. In addition, we have been able to make further progress in modernising our equipment and furnishing our headquarters. In particular, the Council Room has now been introduced for use both by the Council and many of its sub-committees. Much still remains to be done, however, and further donations would be welcome. UK members can increase our funds, at no additional cost to themselves, simply by completing a Deed of Covenant for the amount of their annual subscriptions.

MEMBERSHIP OF THE COUNCIL

President: G.V.E. Thompson
Vice-Presidents: A.T. Lawton
C.R. Turner

Other members: P.J. Conchie
K.W. Gatland
Prof. G.V. Groves
Dr. W.F. Hilton
Dr. W.R. Maxwell
Dr. R.C. Parkinson
Dr. L.R. Shepherd
G.J.N. Smith
G.M. Webb

Accounts

The financial strength of the Society is of paramount importance to all of us, since this is the only way that we can look forward to creating a base for further advance or secure the strength to withstand adversity.

Our accounts reflect a most successful year. The surplus of just over £10,000 is not of major proportions but we have managed to complete much of the planned work outstanding from earlier years and, additionally, reduce our Bank overdraft to manageable proportions. Indeed, if all goes well in 1982, we might hope to to see the end of this indebtedness and the creation by the Society of further assets to enable it to perform its functions yet more efficiently.

The opportunity has also been taken this year to alter the format of our accounts slightly to bring them into line with modern practice.

Library

Our Library is now fully operational and is still slowly expanding, with books being acquired mainly by donation.

Members will know from the Progress Reports in *Spaceflight* that we have a hard-working Library Committee who are attempting to create, both for the Society and for posterity, a fine collection of specialised space and space-related books.

Inevitably, their work is becoming more exacting as rarer and more valuable books are sought. Even the identification of the books and reports which a Society like ours ought to possess is a mammoth task, with an added complication because many are now rare, even though published not more than a few decades ago.

I am very pleased indeed to record the support given to the work of the Library Committee by so many members. Some long-standing workers in the space field have given most liberally of their books and reports, and even personal records in some cases, to the society for safe keeping.

The Library Committee is currently trying to collect items of all kinds for display purposes. We would be more than happy to hear from members with suitable items they are prepared to donate.

Staff

Council records once again its thanks to our staff, who have contributed magnificently to our expanding programme. In 1981 they included the Executive Secretary (Mr. L. J. Carter,) his assistant (Ms. S. A. Jones,), Mrs. J. Arthur, Mr. P. R. Freshwater, Mrs. L. Lawford, Mrs. S. Mandy, and Mr. A. Wilson. Mrs. N. Golovine resigned during the course of the year and Mr. A. Farmer joined our staff in a part-time capacity at the end of the year. I thank all staff for their devotion and for the long hours they work to ensure that our publications go out on time and our meetings are a success. Our thanks are also due to all the members of our committees who have assisted in the work of the Society.

I would like to end this report and my three-year period as President by thanking members for their continuing support. The next President will have the task of seeing the Society through the celebrations marking the fiftieth anniversary of the foundation of the BIS and into the start of its second half-century. I wish him and the Society well and hope that you will continue to help in our work. As a preliminary to these celebrations, may I again remind you the Society is holding a festival event "Space '82" at the Brighton Conference Centre in November 1982. We hope that you will make every effort to attend.

GORDON V. E. THOMPSON

BIS COMMITTEES

Executive

Chairman:	G.V.E. Thompson	
	K.W. Gatland	G.V. Groves
	A.T. Lawton	W.R. Maxwell
Secretary:	L.J. Carter	

Publications

Chairman:	A.T. Lawton	
	G.V. Groves	W.R. Maxwell
	D.M. Holmes	G.V.E. Thompson
	S.A. Jones	
Secretary:	L.J. Carter	

Programme

Chairman:	M.R. Fry	
	J.R. Adams	K.C. Pike
	J.G. Bradbury-Williams	G.F. Phillips
	P.S. Clark	M. Postranecky
	T.J. Grant	T.D. Andrews
	G.V. Groves	R. Holdaway
	A. Kenden	
Secretary:	L.J. Carter	

Facilities

Chairman:	A.I. Lewis	
	A.T. Lawton	G.V.E. Thompson
	W.R. Maxwell	M.W. Wholey
Secretary:	L.J. Carter	

Library

Chairman:	L.J. Carter	
Vice-Chairman:	G.F. Phillips	
	P. Girton	E.J. Shamah
	D.R. Goff	M.D. Smith
	R.D. Hall	G. Statham
	M.N. Irvine	A.A. Thomson
	P.C. James	R. Ward
	C. Ledsome	M.W. Wholey
	D.A. Liddle	M.J. Williams
	G.E. Noad	R.P. Sweetman
	E.L. Parks	
Secretary:	E.M. Waine	

Space Technology

Chairman:	P.J. Conchie	
	R.A. Buckland	T.J. Grant
	G.W. Childs	C.H. Martin
	A.J. Dunlop	G.R. Ramsden
	I.V. Franklin	G.R. Richards
	D.G. Fearn	P.A. Roberts
	R.D. Gould	R.M.B. Shelton
Secretary:	G.M. Webb	

International Liason

Chairman:	L.R. Shepherd	
	E.J.S. Becklake	G.J.N. Smith
	P.J. Conchie	G.V.E. Thomson
	G.V. Groves	G.R. Turner
	C.E.S. Horsford	
Secretary:	L.J. Carter	

Membership

Chairman:	G.V. Groves	
	A.T. Lawton	G.V.E. Thompson
	W.R. Maxwell	G.R. Turner
	R.C. Parkinson	
Secretary:	L.J. Carter	

Education

Chairman:	G.V. Groves	
	J.W. Axtell	D.J. Horne
	E.J.S. Becklake	R.T.H. Jackson
	L.S. Carstairs	C. Ledsome
	S. Clothier	M.J.H. Mogridge
	S.W.H. Cowley	D.H. Smith
	M.J. Fowler	P.J. Tortise
	T. Furniss	R. Ward
Secretary:	J.C. Gilbert	

History Working Group

Chairman:	E.J.S. Becklake	
	R.D. Gould	I.E. Smith
	J. Griffiths	T.G. Treadwell
	P.D. Penny	L.R. Shepherd
Secretary:	J. Harlow	

CORRESPONDENCE

Terraforming Venus

Sir, Saul Adelman has apparently overlooked some basic physics in his article "Terraforming Venus" in the February issue. One quickly realises that a simpler alternative to forcing asteroids into retrograde orbits would be to slow their existing, prograde motion to the point that they simply "fall" into Venus. Cranted, the impact velocity would not come near to 90 km/sec, but there is an important secondary consideration: collisions with retrograde asteroids, as Adelman envisages, would also reduce Venus' orbital motion, moving it closer to the Sun and effectively reducing the net terraforming efficiency of the event. On the other hand, prograde collisions provide the "bonus" of increasing the planet's orbital motion, thus moving it farther from the Sun and consequently lowering both its black-body and greenhouse surface temperatures.

J. KELLY BEATTY
Associate Editor
"Sky and Telescope"

Centaur

Sir, On p. 88 of the February issue of *Spaceflight* is a picture that shows Deane Davis gesticulating to Wernher von Braun in an ambiguous manner. As you point out, he may be giving the familiar "OK" sign or something more fundamental and Anglo-Saxon in its immediacy and succinctity.

However, you fail to identify two other persons in the picture. To von Braun's right is an old colleague from Peenemuende: Krafft Ehricke, who worked for Convair on the Atlas and who made an early proposal for utilising that vehicle as a manned orbiting laboratory. Just to Ehricke's right is an even older acquaintance and colleague of von Braun from Peenemuende. He is Hans Hueter, who helped to design a launching container for V-2 missiles that would be towed by German submarines to positions off the coast of the USA just as World War II was in its final days. While not in the picture, since he died in 1953, there must have been there in spirit Dr. Hans R. Friedrich, also a colleague of von Braun, Ehricke, and Hueter at Peenemuende. As a member of the Convair Atlas team, he made many contributions to its guidance and control system. Atlas missile 10B, launched only a few weeks after his death, was informally dedicated to him and became better known as Project Score, an Atlas orbiting the Earth and transmitting a "Happy Christmas" message to the world from President Eisenhower.

MITCHELL R. SHARPE
Huntsville, USA

The Shuttle and Beyond

Sir, Where do we go from here with the US Space Transportation System? Here are some thoughts of my own, followed by my recommendations.

Basics

(a) We are firmly committed to using the form of the present Shuttle. In order to maintain some credibility to past (often wild, I admit) promises, this bird has to be used over the next 10 to 20 years;

(b) Everybody but dreamers knew about the true Shuttle transportation costs at least seven years ago (see relevant publications by the late Val Cleaver). Present data are no surprise;

(c) Choosing the IUS as the Shuttle upper stage was an incredibly poor decision. A reusable tug is wrong, also. What is required is a high-energy expendable upper stage not necessarily pushed to its performance limits. My bet is an adaption of the Centaur (see Fig. 1);

(d) We should not develop a new orbital carrier now. I think the Shuttle plus a Shuttle-derived HLV is all we need for some decades to come (see Fig. 2). The large traffic required to justify a fully reusable carrier is unrealistic;

(e) A launch cost of \$5-50 /kg into orbit is a pipe-dream for some time;

(f) Reusable Single Stage-To-Orbit (SSTO) vehicles are neither possible technically nor economically.

My recommendations

1. Make the Shuttle work;
2. Adapt Centaur as an upper stage;
3. Develop a Shuttle-derived HLV,
4. Use the Shuttle: make good use of Spacelab, go for a space station programme, start a carefully planned "production-in-space" programme, keep up present space-based science,

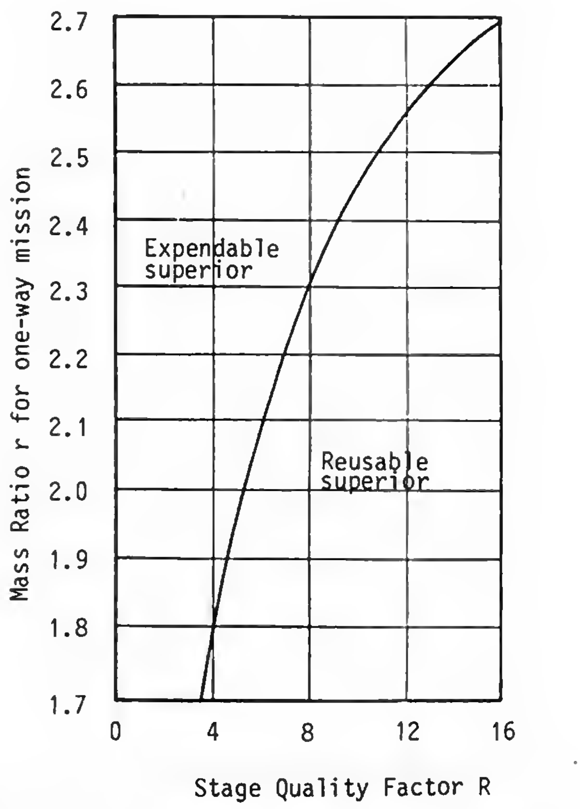


Fig. 1. Assume that we have an upper stage ("tug") in the Shuttle bay. The stage quality figure, R, is the mass ratio of this stage without any payload. This stage has a job to do, i.e., transport some payload from the Shuttle low-Earth orbit to some other orbit. The required mass ratio for this is r. We have two ways of doing this job: with an expendable Stage or with one that returns to the Shuttle on its own for reuse. The diagram shows the conditions for which one or the other type of stage is more suitable. The assumptions behind the curve roughly describe Shuttle-reality, and are too involved to be described here. The result is based on economics and not on performance, etc. It shows that transport to geostationary position should be in an expendable mode.

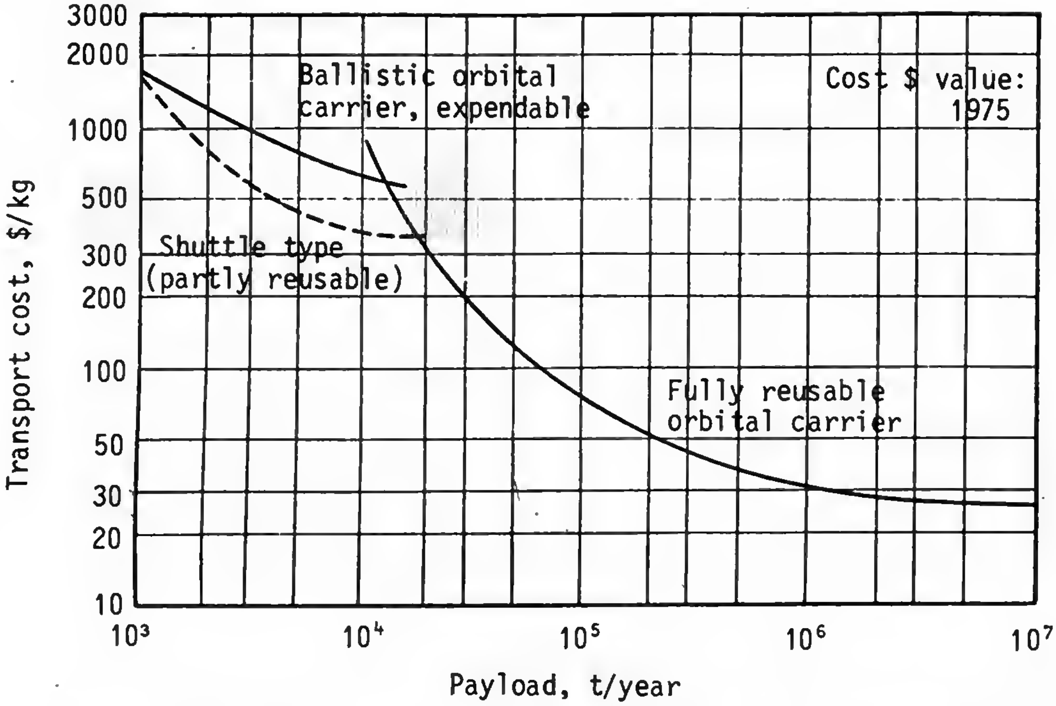


Fig. 2. The yearly transport volume in metric tons to low Earth orbit against transport cost (payload or orbital operations cost not included; but launch and launch base costs are) in $/kg deliver to this low orbit.

Major assumptions are: 1) The yearly transport volume (in metric tons) to low orbit is given and fixed (call this "the job"); 2) Only one carrier vehicle is utilised, this is optimised (cost-minimised) for the job to be done; 3) All flights go to low Earth orbit; and Price and Dollar value: ca 1975.

The curves show that below a launch rate of 1000 tonnes/year to LEO we should use an expendable ballistic launcher; between 1000 and 17,000 tonnes we should use a Shuttle-type vehicle; and above 17,000 tonnes a fully reusable launcher. At this lower level cost is $370/kg but if we launch 10^7 tonnes/year into LEO that figure comes down to $25/kg.

improve the things we can do (communications, navigation, etc.);

5. In doing 4, I would hope that we can get: a reusable upper stage for its field of applicability, solar-electric propulsion developed, nuclear reactors for astronautical applications, adapt the latter for electric propulsion, an electric geostationary (reusable) tug, better life-support systems, space-based "deep space network", knowledge of how to live and work in space, knowledge of space-operations;

6. We "space cadets" clearly need a large, universally-accepted space programme, funded from a non-space activity. I see only one realistic chance: nuclear waste disposal. (My choice is high Earth orbit but this detail is not important at the moment.) This could start around the year 2000, partly as a consequence of point 4 above proceeding well. This programme would easily be large enough to make the scope of all our other space activities appear small. And it would provide enough traffic volume to render space transport reasonably cheap (see Fig. 2) and possibly allow the introduction of a new (more desirable) carrier. Thereafter, manned exploration of the Moon and Solar System might even be conceivable.

7. I agree that power satellites are not economically viable. This might look better after point 6 comes about. So I would keep some small efforts going, under point 4.

8. Space Cities (à la L5), atmosphere on the Moon, large space factories, I would leave to Science Fiction for several decades. After point 6 I would reconsider these ideas. At that time, our controlled fusion friends might have gotten somewhere (this could deserve a good look, too).

I think wild promises are as dangerous to our own goals as the combined efforts of all the sceptics. I feel honesty, realism and expertise are demanded of us. Impossible to foot this bill, no; difficult, yes. If we continue to fail as we have done over the past decade or so (no leadership, and solid work replaced by unfulfillable promises, self-deception and superficiality), then we have no-one but ourselves to blame.

Prof. H. O. RUPPE
Munich

Manned Exploration

Sir, It is early February and I have just received my January issue of *Spaceflight*. Thus I was unable to respond earlier to the announcement on the inside front cover that a discussion of manned exploration of the planets would take place at the BIS Headquarters on 13 January 1982. I would loved to have shared a portion of the evening with you as this topic remains near and dear to my hopes and expectations for the future.

The announcement stated that NASA has not looked at manned planetary flight for over ten years. This is not strictly correct. It is true that over a decade has passed since a thorough and basic study of a manned planetary mission was completed and this study was, of course, widely publicised. A manned planetary mission was considered as a major "new start" at the time of the Shuttle decision. Economics dictated that the USA space effort should give priority to near Earth operations, and the development of systems for deep space manned operations, particularly the Nerva nuclear rocket, were terminated.

However, low level studies have been continued by NASA with emphasis on how a manned Mars landing could, for example, be carried out utilising the Space Shuttle as the primary booster system and incorporating on-orbit assembly of modules for the flight system. Such a system is deemed feasible and closely resembles the mission described in the

early 1970's based upon Saturn launch vehicles.

I urge the BIS to continue to stimulate thinking for expansion of the planetary exploration effort. Such a goal is an inevitable outcome of the excellent progress in space seen during this last half of the 20th Century. That man has become a spacefarer and has achieved a gigantic step forward is established; however, a period of consolidating this knowledge for the benefit of our well-being on Earth is a proper policy and result.

We should all remain alert for the proper timing of the "next giant leap."

ROBERT F. FREITAG
Deputy Director, Advanced Programs,
Office of Space Transportation Systems, NASA

Recovery of Spacecraft

Sir, Regarding my article "The Recovery of American Manned Spacecraft, 1961–1975" which appeared in the April issue of *Spaceflight*, I would like to say that the choice of photographs was excellent.

There are one or two corrections to note: Apollo 8 landed in the Stable 2 position, while Apollo 13 did not. Also, the Apollo 14 astronauts *did* spend time in quarantine.

K. T. WILSON
Strathclyde, Scotland

Paradise Lost?

Sir, Perhaps you have been keeping up with the attempts of a certain group to launch a "poor man's rocket" from Matagoras Island off Texas. The mainspring behind this group is a Texas multi-millionaire named David Hannah, a man whose professed hobby is Space – and the money to indulge his hobby. He has set up an organization called Space Systems Inc (SSI) with a formidable board of directors (Deke Slayton amongst them). Their intent, they advertise, is to provide a commerical Space Transport System (their capitals), employing everything from east-west/polar to geosynchronous-equatorial orbits. Considering the pile of spare solid boosters they intend to paste together to achieve all of this their plan seems to be pretty grandiose, but remember what they said about Alexander Graham Bell!

Nevertheless, they are pressing forward and they are searching the USA for more suitable launch sites than Matagoras (I don't blame them, having been there). One of the sites in which they have expressed a major interest is the extreme southern tip of the island of Hawaii (the Big Island on which I live). A casual look at a map will explain why: it's the southernmost point in the United States (good for geostationary orbits) and has wide open ocean (WOO) in all directions which eliminates the overfly problems (but brings on tracking difficulties. Well, there are boats; perhaps they can rent one of the Russian trawlers which seem to live twelve miles off-shore in these parts). I'd have picked the place myself.

The hitch is, South Point (Ka Lei, in Hawaiian) is sacred to the native Hawaiians being the place where, historically, the originals arrived from Tahiti. It is also the place which, a thousand years ago, the aborigines used as their northern base for the Tahiti-Hawaii-Easter Island voyages. It is the Tyre of the Pacific. It's a lonesome, panoramic, mysterious, silent place with a soul-shattering grandeur about it.

With that as a background you might get a slight idea of the local uproar when SSI's plans were announced. The residents of the surrounding district brought along ripe eggs and tomatoes to the first general meeting on the subject – and used them. In the midst of all of that they sought me out and asked me to be their adviser on the matter, a job that I've accepted.

It appears that I will be squarely in the middle of the first Space vs The People encounter that this world has seen.

Aloha!

DEANE DAVIS
Hawi, Hawaii

For many years, Mr. Davis was in the space business himself; he was intimately involved with the Centaur upper stage. We were fortunate in having him as a Guest of Honour at our "First Night" meeting last October – Ed.

Where Am I?

Sir, I was amused to see Yvonne Cooper's letter (*Spaceflight*, March 1982, p. 143). A taxi driver could well have had trouble finding the old HQ even if he found Bessborough Gardens, because although that was the postal address it was actually on the corner of Vauxhall Bridge Road and John Islip Street, with the door facing the latter – the reason for this being, I think, unknown even to the Executive Secretary!

On my only visit there I had great trouble finding it, even after having found Bessborough Gardens!

RAY WARD

The Editor is always interested in receiving items of correspondence, notes, comments, or reviews for possible publication. Items submitted must be kept brief, owing to the limitations of space in our magazine. The Editor reserves the right to shorten or otherwise adapt material to fit, for this reason.

SNIPPETS

Thanks

Sir, Thanks for all the good work and the high standard of professionalism. The BIS gets more substantive as the 50-year mark nears!

D. WEBBER
Bucks

To the Executive Secretary:

Sir, You have got to be the plus perfect executive secretary and archtypical type for any professional organization in the world. Each letter makes me dig into the filing cabinets and closets looking for odds and ends I have long forgotten.

MITCHELL SHARPE
Huntsville, Alabama

I'll Be There

Sir, I hope to visit England in 1983 and I will have to visit the BIS as a top priority of my itinerary.

F. J. HOWELL
Canada

Apologies

Sir, I still find the Society the best in the world.

JOHN AUCHETTL
Cheltenham

Satellite Digest

Sir, I would like to say how much in favour I am of the new style of Satellite Digest in *Spaceflight*. Indeed, all the articles in *Spaceflight* continue to be as interesting as ever.

P. A. HEARD

We Try Our Best

Sir, I don't know how you manage to keep up such a high standard with such limited resources, but I would like you to know how much it is appreciated.

N. B. KEARY
Berks

ISSN 0038-6340

SPACEFLIGHT

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VOLUME 24 Nos. 9 & 10
SEPTEMBER - OCTOBER 1982

JOIN US AT BRIGHTON 12 – 14 NOVEMBER FOR

SPACE '82

A VISION OF THE FUTURE

Space '82 will provide an excellent opportunity for Members and their guests to meet the people making space history. Top speakers from the world of astronomy and astronautics will present lively views on how Mankind will expand into the Universe and what benefits we can expect.

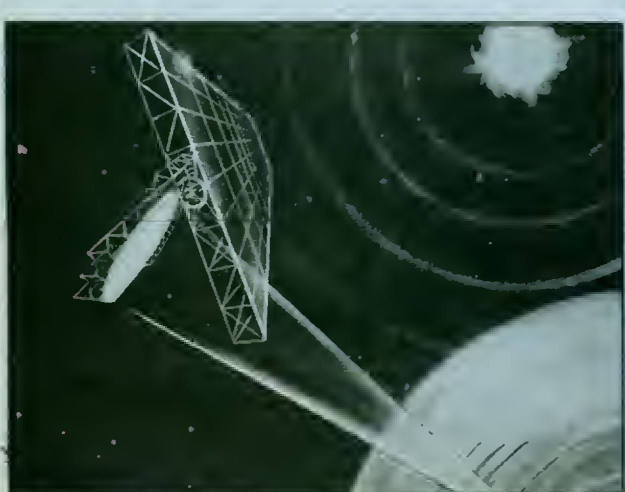
A particularly interesting session will be held on the theme of the 1985/86 return of Halley's comet. Probes to Halley will be launched by Europe, the USSR and Japan in an effort to answer fundamental questions about the early history of the Solar System. Our chairman will be Dr. D. W. Hughes who can be said to have originated the European *Giotto* probe scheme with his paper "The Direct Investigation of Comets by Space Probes" which appeared in the Society's *Journal* in 1977. Dr. R. Reinhard and R. M. Jenkins, responsible for the scientific and engineering aspects of *Giotto*, respectively, will add to our coverage of this major event with overviews of how the spacecraft will work and what it will do:

Dr. R. Reinhard	:	Giotto: The Exploration of a Comet.
R. M. Jenkins	:	Journey to Halley's Comet.
Dr. D. W. Hughes	:	Halley's Comet: Its History & Future.

The Shuttle provides the path to the exploitation of space. Ex-NASA Administrator Tom Paine and Raefe Shelton of British Aerospace will take on the task of reviewing space industrialisation. Burt Edelson, just appointed as NASA's Associate Administrator for Space Sciences and Applications, will consider that vital topic of "World Space Communications".

Provisional titles for other talks scheduled are:

Patrick Moore	:	Mars – Man's Next Target?
Dr. G. Mueller	:	Space in the 21st Century.
Dr. R. C. Parkinson	:	Staying on the Moon.
Dr. G. Hunt	:	Exploration of the Solar System.
Capt. R. F. Freitag	:	How NASA Sees the Future.
Dr. A. R. Martin	:	Is Mankind Unique?
Prof. M. S. Longair	:	Space Telescope.
E. Quistgaard	:	Space: New Opportunities for Man.
Prof. M. Rees	:	The Universe at our Fingertips.
Ted Mallet	:	Europe in Space.
Dr. W. I. McLaughlin	:	Evolutionary Pathways for Man & Machine.
H. J. P. Arnold	:	Space Kaleidoscope.
Dr. P. A. Penzo	:	Deep Space Exploration.
Major P. A. Swan	:	Developing Future Astronauts.



One of our Space '82 speakers, Raefe Shelton, is a leading expert on solar power satellites.

Banquet

Saturday evening will be highlighted by an optional banquet in the Metropole Hotel with Guests of Honour giving topical talks about the space scene. These will include Reg Turnill, veteran space reporter, Olof Lundberg, Director General of the newly-created Inmarsat, and Cyril Turner, Technical Secretary of Eurospace.

The evening will give everyone the opportunity to meet a host of space pioneers. The Banquet will cost £12 (excluding wine and spirits which can be purchased separately).

Exhibition

Participants will be delighted to know that arrangements are underway for a number of space exhibits to be on display in the Foyer Hall. The European Space Agency have already agreed to include models of: Ariane, Space Shuttle, Giotto, Marecs and the Space Telescope. We hope to include other displays from British Aerospace, Inmarsat and British Telecom. Brighton Museum will also be holding a Science Fiction exhibition (details available on 0273-603005, ext. 44).

A Special Invitation to Provincial and Overseas Members

If you haven't been to a Society meeting before, why not come to Space '82? Your Council and Officers and leading members of committees will all be there to greet you. What better time could there be to come and say "Hello"?

Continued on inside back cover

SPACEFLIGHT

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Founded 1933 *Incorporated 1946*

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CONTENTS

338 **Watchers in the Skies** *Dr. R. Harris*

342 **Space at JPL** *Dr. W. I. McLaughlin*

345 **Space Communications**

348 **Space Report**

358 **The Ariane Launcher** *Bruno Gire*

365 **News From The Cape** *Gordon L. Harris*

370 **Satellite Digest – 157** *R. D. Christy*

373 **Society News**

376 **Society Meetings**

COVER

SPACE '82 LOGO. This attractive, colourful design for our exciting Space '82 weekend in Brighton on 12–14 November is available on a T-shirt. See the inside back cover for details. Other information on Space '82 can be found on both inside covers.

MILESTONES

April 1982

7 Space Shuttle Main Engine 2013 is destroyed by fire during a test run at the National Space Technology Laboratories. The original failure is believed to have occurred in the high pressure fuel pump. The fire will delay acceptance testing of Orbiter *Challenger's* engines by about a month.

19 Salyut 7 is launched into a 219×278 km orbit. On 13 May the Soyuz T-5 craft with cosmonauts Anatoli Berezovoi and Valentin Lebedev is launched and docks with the new space station on 14 May. A three man crew with a French cosmonaut is expected to fly in June. On 15 May the orbit is 343×360 km.

19 NASA announces that Sally Ride will fly aboard the seventh Shuttle orbital mission in April next year as a mission specialist. Bob Crippen and John Young, who flew the first orbital mission, will command STS-7 and STS-9, respectively. Dick Truly of STS-2 will command STS-8.

22 Engineers manage to free the jammed C-band antenna of the Indian Insat 1 communications/meteorological satellite by firing a 22 N thruster. The first attempt failed.

26 COS-B, ESA's gamma-ray astronomical satellite, is switched off after operating for almost seven years. Its design life was two years.

May 1982

11 A Big Bird spy satellite is launched by Titan 3D from Vandenberg Air Force Base in California.

12 ESA announces that the launch of Ariane L5, carrying Marecs-B and Sirio 2, has been delayed until 10 September. Marecs 1, launched last December, has suffered electrostatic problems in orbit and modifications are being made to the second craft. Exosat will now fly aboard Ariane L6 in November.

17 The Soyuz T-5 cosmonauts release the 62 lb Iskara 2 amateur communications satellite from Salyut 7. It will be controlled by students from command centres in Moscow and Kaluga.

17 A new group of cosmonauts, including women, is in training at Star City near Moscow, claims *Aviation Week*. The Soviets have usually maintained that men are better suited to space flight.

AN IMPORTANT NOTE TO MEMBERS WHO FORMERLY PAID BY BANKERS ORDER

Please note that, as from 1 January 1983, the Bankers Order System is being superceded by the Direct Debit Scheme. Introducing the new scheme smoothly makes it essential that all members who formerly paid by Bankers Order complete and submit their Direct Debit slip. Those members who have not already done so *are urged to deal with this without delay*. Duplicate Direct Debit slips are available from the Executive Secretary on request.

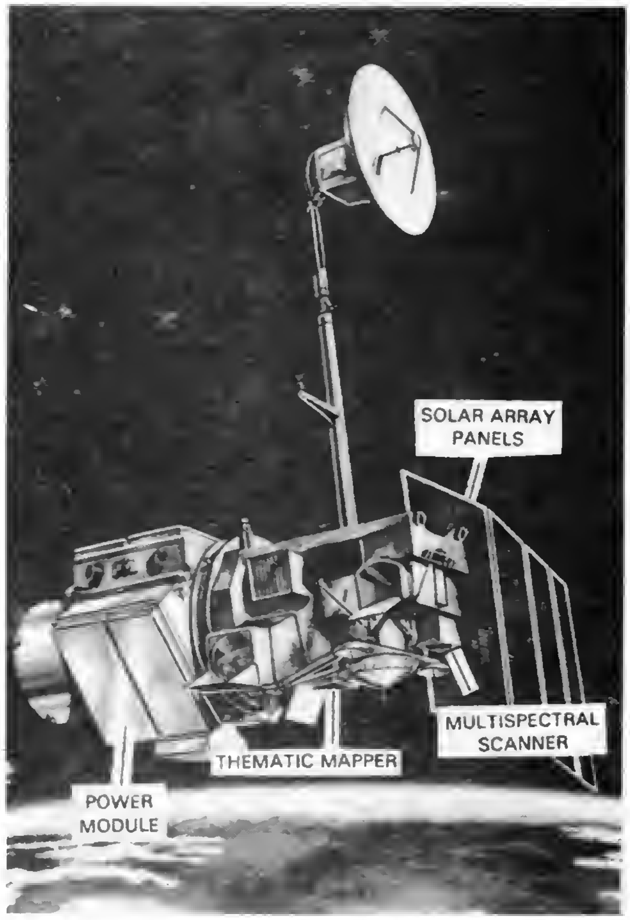
A Note for New Members: The advantages of using the Direct Debit Scheme are so great that all members who normally pay by cheque are urged to use it. It merely requires the completion of one simple form which has then to be sent to your bank. Thereafter, the annual subscription arrangements are dealt with automatically, with adequate safeguards to rectify mistakes and keep your account straight. It will rid you of your subscription chore and *it won't cost you a penny more!*

WATCHERS IN THE SKIES

By Dr. R. Harris*

A NEW MEMBER OF THE LANDSAT FAMILY

The launch of the Landsat 4 remote sensing satellite is part of a continuing US programme to observe the Earth in great detail from orbit. Such information is being used to map crop production, flooded areas, natural disasters, deforestation, snow melt, sea state, geology, atmospheric pollution, ice flows, rangelands and many other environmental features. If Landsat 4 repeats the success of its predecessors then the 1980's will continue to see exciting imagery from space of vital features of the Earth.



Landsat 4 is approximately 1.8 m high. The data from the Multispectral Scanner and the Thematic Mapper is transmitted to Earth from the antenna at the top.

NASA

Landsat D

NASA launched its latest Landsat satellite from Cape Canaveral in July using a Delta 3920 expendable launch vehicle. Upon successful insertion into orbit it became Landsat 4, the fourth of the successful Earth resources satellites which started from the Earth Resources Technology Satellite (ERTS) programme of the late 1960's and 1970's. Landsat 4 joined its three sister satellites in near polar orbits to continue the task of collecting information about the Earth on a repetitive basis. There are now two such satellites capable of data collection (Landsat 1 stopped functioning in January 1978 and Landsat 2 in February 1982), and they are able to transmit back to Earth pictures in digital form such as the picture of northern England accompanying this article. Landsat 4 will, however, be able to look at such areas in considerably more detail, both spatial and spectral, than its predecessors.

The observatory has a different configuration from its predecessors since its design was based on the multi-mission modular spacecraft (MMS) philosophy [1]. Future MMS vehicles will be launched not directly from the ground, but will be carried into orbit by the Space Shuttle and launched (and indeed retrieved) from there using the Shuttle's articulated arm. The satellite stands approximately 1.8 m high, and is powered from solar panels via a power module.

The Sensing Instruments

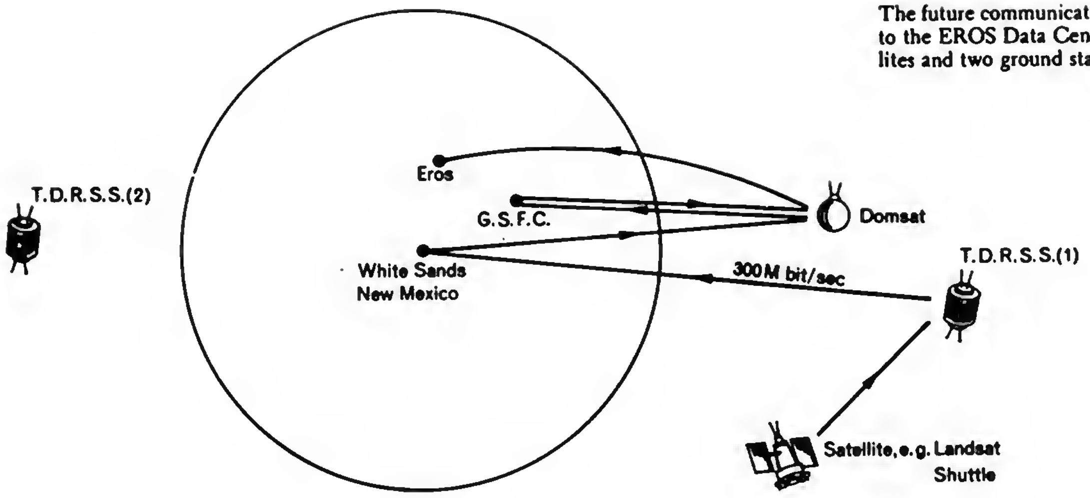
Landsat 4 carries two principal remote sensing instruments: the Multispectral Scanner (MSS) and the Thematic Mapper (TM) The MSS senses in the same four wavebands as its predecessors (green, red and two near infrared bands), and its ground instantaneous field of view (spatial resolution) is 80 m. The Thematic Mapper is a new instrument with increased spatial and spectral abilities. It has a ground instantaneous field of view of 30 m, operating in seven spectral bands, including visible, near infrared and thermal infrared.

The new near infrared bands should prove particularly useful in mineral exploration and in mapping vegetation stress and soil types. Landsat 4's orbit gives it a descending (north-south) equator crossing at about 9.30 a.m. It will maintain a 16 day revisit cycle, and each image frame will provide a ground coverage of 185×170 km.

Communications

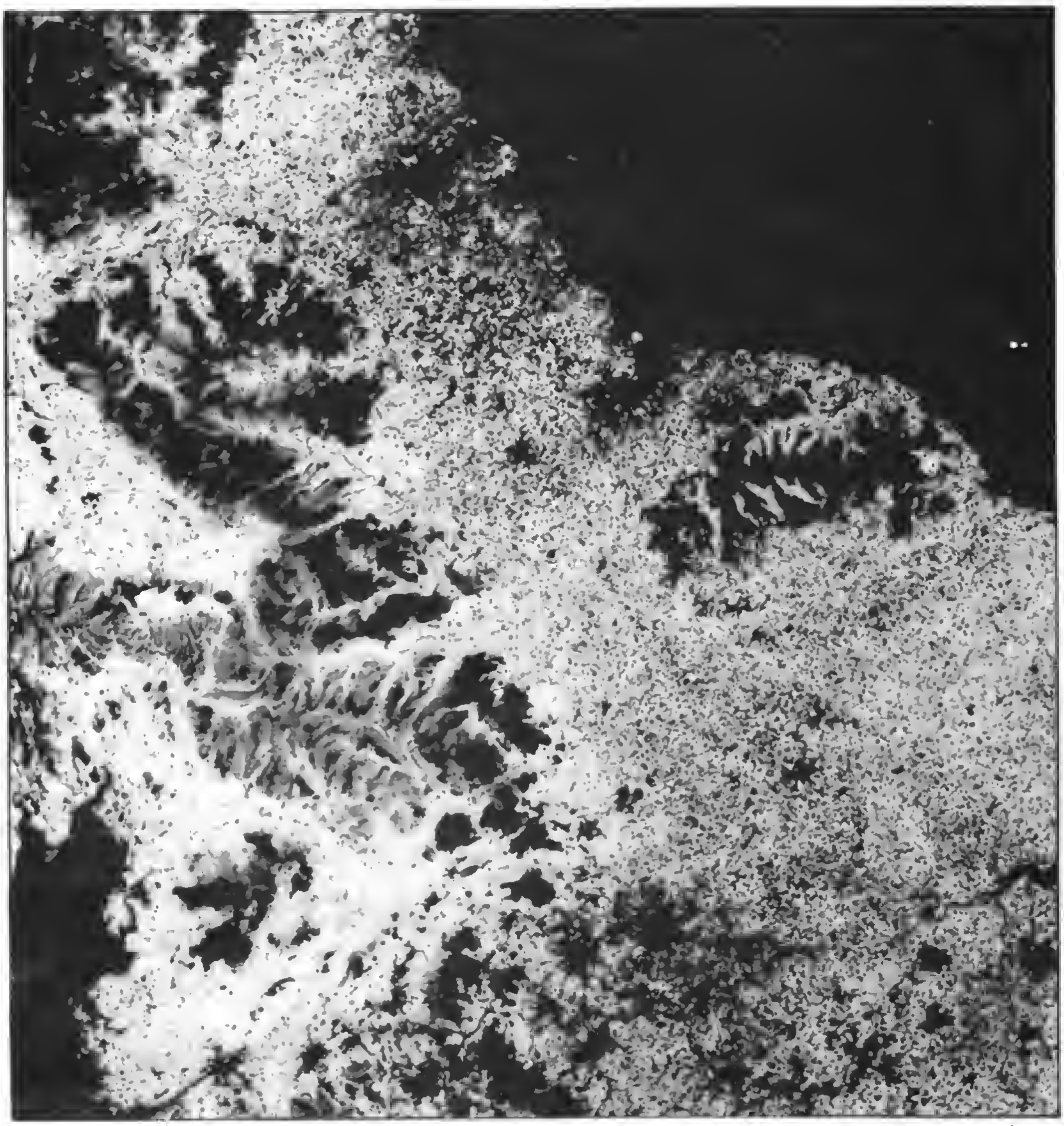
One new aspect of the new satellite's activity is its communication with the EROS Data Centre (EDC). When fully operational in 1984, it will communicate data via a series of communication links. Image data will be transmitted to one of two geostationary Tracking and Data Relay Satellite System (TDRSS) satellites, and from there the data will be transmitted to a ground station at White Sands in New Mexico. After some preliminary processing, the data will then be transferred to NASA's Goddard Space Flight Center via the US domestic satellite Domsat, from where the data will be transmitted to the EROS Data Center in South Dakota, again via Domsat, for final product generation and archiving. This scheme means that the EDC will be in direct data contact with Landsat 4 throughout its whole orbit, with the exception of a "blind spot" over part of the Indian Ocean. The TDRSS will also be used to transmit command and telemetry signals to Landsat 4, and will operate the same functions with other US satellites such as the Space Shuttle. The key to the success of the TDRSS concept is the massive data rate: 300 million bits (0–1) of information can be transmitted from one TDRSS each second in the K-band. Local ground stations below the path of Landsat 4 will still be able to receive data by direct transmission from the satellite, at 15 million bits per second for MSS data (S-band) and 85 million bits per second (X-band) for TM data. Both the use of the TDRSS and direct transmissions to non-US ground stations means that there is no necessity for an onboard tape recorder to record the data: this has been troublesome in the past because of its noise problems, reliability

* *Dept. of Geography, University of Durham.*



The future communications links from Landsat to the EROS Data Center via two other satellites and two ground stations.

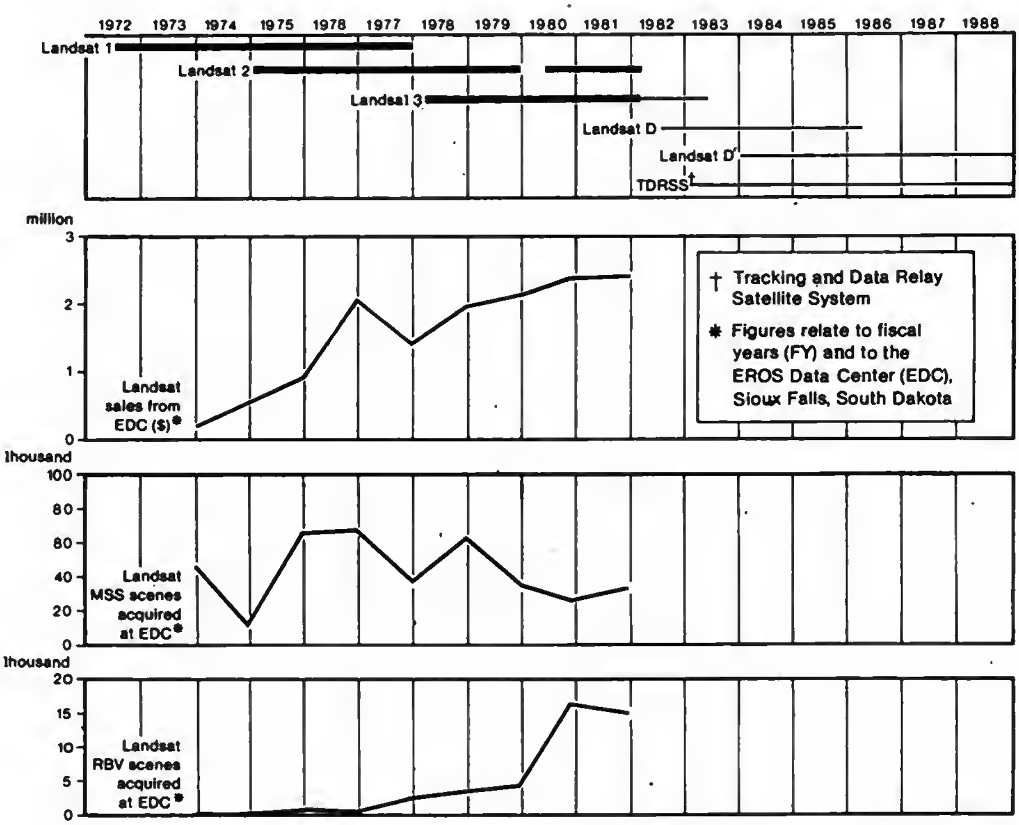
Below: A Landsat 2 band 7 (0.8–1.1 μm) image of northern England, 27 May 1977. The Tyneside and Teesside conurbations are clustered around their respective rivers flowing into the North Sea; the moorlands of the Pennines and the Lake District are evident on the left; the patchy agriculture of the Vale of York is on the right.



	Landsat 3	Landsat 4	
	MSS	MSS	TM
Bands			
1			0.45- 0.52 μm
2			0.52- 0.60 μm
3			0.63- 0.69 μm
4	0.5-0.6 μm	0.5-0.6 μm	0.76- 0.90 μm
5	0.6-0.7 μm	0.6-0.7 μm	1.55- 1.65 μm
6	0.7-0.8 μm	0.7-0.8 μm	10.4 -12.5 μm
7	0.8-1.1 μm	0.8-1.1 μm	2.08- 2.35 μm
8	10.4-12.6 μm		

Table 1. A comparison between Landsat 3 and Landsat 4.

Ground resolution Landsat 3 79 m (Band 8 237 m); Landsat 4 80 m for MSS, 30 m (Band 6 120 m) for TM. **Orbital altitude** Landsat 3 920 km; Landsat 4 705 km. **Revisit cycle** Landsat 3 18 days; Landsat 4 16 days. **Scene ground coverage** Landsat 3 185×185 km; Landsat 4 185×170 km



Landsat operations and EROS Data Center activity from 1972, and plans for Landsat satellites to 1988.

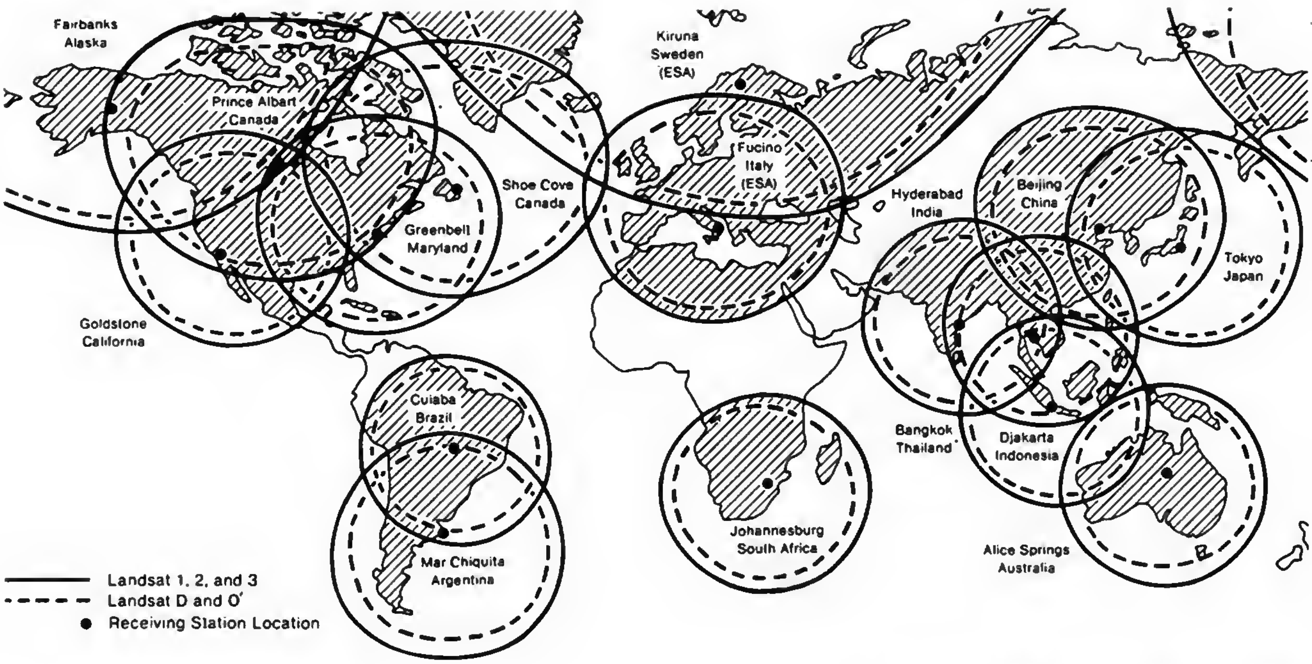
and the extra weight carried into orbit.

Concurrent with the development and construction of Landsat 4 an identical spacecraft is being built as a backup: Landsat D' (D prime). This satellite will be available in about a year and will be launched when Landsat 4 fails, although this is not expected to occur until 1985 at the earliest. Previous Landsat satellites had design lifetimes of 12 months, but each has been successfully collecting data for five years, so it is to be hoped that the new satellites will be providing useful data to the end of the 1980's.

Landsat Programme

Landsat 1 was retired from service in January 1978 after providing excellent quality Earth imagery of most parts of the land surface of the globe. From January 1975 to January 1978 there was an overlap of Landsats 1 and 2, and their orbits were paired together so that a nine day revisit cycle could be achieved. In January 1980 Landsat 2 developed a flywheel problem which affected its attitude control, but this was cured by June 1980 and the craft was brought back into service. In March 1980 a reduction in its solar array power supply occurred, restricting MSS data transmission to about 20 minutes per day, although this was later increased to 28 minutes per day. By this time, Landsat 2 had become the prime satellite for the Multispectral Scanner because of the failure of its onboard tape recorders. Landsat 2 has now been retired from service.

From March 1978 to February 1982 there was an overlap in operations of Landsats 2 and 3. However, Landsat 3 has proved technically more troublesome than its predecessors, so it is designated as the prime spacecraft for Return Beam Vidicon (RBV) data acquisition. RBV cameras operating in three spectral bands of the visible and near infrared wavelengths were carried by Landsats 1 and 2, but proved rather unsuccessful. On Landsat 3 a single broad band RBV camera was carried with a wavelength sensitivity of 0.505–0.750 μm, and this has



Part of the Landsat receiving station coverage.

proved much more successful. The RBV camera operates by electronically scanning a photosensitive camera tube plate, unlike the MSS which is an electro-mechanical scanner. Results from the RBV in areas of high contrast have been good, with a ground resolution of up to 30 m. Landsat 3 also records some MSS data on its onboard tape recorder, but the MSS data have been subject to technical problems including late line starts causing the loss of some lines of an image, multiplexer problems causing data degradation, and a command/clock equipment failure which curtailed all Landsat 3 operations during July 1981.

At the beginning of the Landsat programme, only receiving stations in the United States could receive Landsat data. Since 1972 the number of receiving stations has increased, and now 14 stations can receive data from direct transmissions, and several more are planned. Only parts of central America, central Africa, the Middle East and the USSR are not covered by ground receiving stations. Their proliferation attests to the success of Landsat, and to the needs of many countries to acquire Earth imagery.

The success of the operations can be seen from the lower part of the "Landsat operations" diagram. The data shown relate solely to the EROS Data Center (Sioux Falls in South Dakota) which is the main Landsat data archive, and the information is organised by US fiscal years. Tens of thousands of MSS scenes have been acquired at the EDC since the start of the Landsat programme, and since the launch of Landsat 3 thousands of RBV scenes have also been acquired each year. This has generated sales of over $2 million of Landsat products per annum from the EDC alone. Worldwide sales from the EDC and the non-US receiving stations amounted to over $4 million in 1980, of which the USA accounted for 69 per cent, Canada and Brazil 9 per cent each, Europe 8 per cent and Japan 3 per cent. The prices charged for Landsat products reflect the administration and distribution costs incurred by the data centre, and not the capital and running costs of maintaining the Landsat satellites. From 1 October 1982 the US agencies increased their prices of all Landsat products to try and recover the operating and maintenance costs of the Landsat 4 MSS programme and its associated data processing. The prices of Landsat data will increase approximately threefold.

Conclusion

The reason for the price increases for Landsat products is the transfer of responsibility for the Landsat programme from NASA to the US National Oceanic and Atmospheric Administration (NOAA). From 1 October Landsat assumed a semi-operational status, and as NASA's remit covers only experimental satellites the managerial responsibility for Landsat was transferred to NOAA. Because of this semi-operational status of the Landsat programme NOAA is attempting to recover the full costs of Landsat's operational instrument, the MSS. This commercial view of Landsat reflects the US administration's political policy, and is also one step along the road to "privatisation" of the Landsat programme. Commentators in the United States have suggested that Landsat may be sold to US private industry by the 1990's, converting the experimental programme of 1972 into a commercial venture which will cull profits from imaging the Earth's surface. It is likely that at that stage Landsat data will be considerably more expensive than the new figures. If the private sector does not take over Landsat operations, then it is likely that the US civil land remote sensing programme will come to an end.

Outside the United States, other countries have been developing satellites with capabilities similar to Landsat. In Europe, France intends to launch its first SPOT satellite in 1984. SPOT will have a maximum ground resolution of 10 m, will be capable of providing stereoscopic coverage of the ground, and will have a revisit cycle of approximately 2½ days. The European Space Agency plans to launch its ERS satellite in 1987. ERS will have an imaging active radar to enable it to see through clouds, so important for the cloudy European region, and to collect information on sea state, useful for North Sea oil operations. Japan plans to launch its MOS satellite in 1984, with instruments similar to those carried by Landsat 4.

REFERENCES

1. Doyle, F. J. (1981) Satellite systems for cartography, *ITC Journal* 1981-2, pp. 153-170.
2. Landsat Data Users Notes (1978-present), US Geological Survey, EROS Data Center, South Dakota.
3. US Geological Survey (1979) *Landsat Data Users Handbook*, Revised edition, EROS Data Center, South Dakota.

SPACE AT JPL

By Dr. William I. McLaughlin

The Jet Propulsion Laboratory in California is a key centre in the exploration of the Solar System and a powerful producer of ideas for new and exciting space ventures.

Here, Bill McLaughlin of JPL, a speaker at our Space '82 conference in Brighton next November, begins a series designed to keep us up to date with recent developments.

IRAS

The first satellite-survey of the celestial sphere in the infrared portion of the spectrum will be accomplished by IRAS, a cryogenic satellite scheduled for launch into a 900 km, Sun-synchronous orbit late this year (see *Spaceflight*, May 1978, pp. 187–191). The project is an international endeavour, with JPL managing the US half, The Netherlands managing the European half, and the UK supplying the tracking station and associated support at the Rutherford and Appleton Laboratories near Chilton, England.

Data taken by the 60 cm telescope (sensitive in the 8 to 120 micron range) will be stored on a tape recorder and dumped twice per day during passes over the Chilton station. These data are electronically transferred to JPL and processed by the Scientific Data Analysis System (SDAS), which is based upon a highly sophisticated set of computer programmes designed specifically for IRAS data processing.

The basic processing will be accomplished on an IBM 3032 and the primary product will be a catalogue of infrared point sources, primarily stars and galaxies. Somewhere between 250,000 to 1,000,000 such sources are expected. This catalogue should serve generations of astronomers as a guide to the infrared sky and as a research tool to assist in identifying interesting objects suitable for more detailed study.

Although the telescope does not directly produce photographic products, SDAS processing will yield photographic-like representations of large regions of the sky in order to show bulk distribution of stars, dust, and gas.

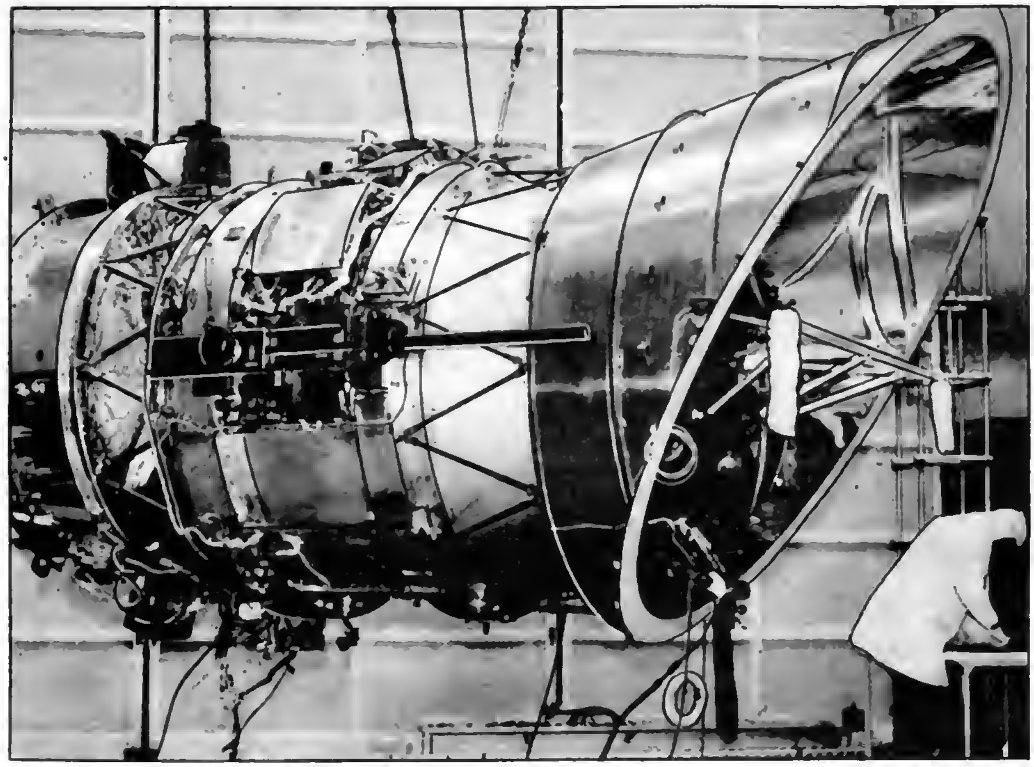
After an initial "shakedown" period of two to three months following launch, SDAS will process data within a few days of receipt at the ground station. This prompt analysis will assist mission planners in their assessment of mission progress, and may result in changes to the strategy of sky coverage.

The JPL project manager for IRAS is Gerald M. Smith. John H. Duxbury manages SDAS, and Dr. B. T. Soifer of Caltech is the principal science advisor for SDAS matters.

JPL ROLE WITHIN NASA

Considerable attention has been given in the popular and scientific press to the decline of the US programme of Solar System exploration under the Reagan administration. Evidence for this decline includes the decisions not to proceed with the Halley and VOIR missions and the cancellation of the US spacecraft for the International Solar Polar mission. Since JPL is the principal centre for planetary work within NASA, questions have arisen concerning the continuing viability of the link between the two institutions.

James Beggs, the NASA Administrator, made clear his position on this subject in hearings before congress on the 1983 budget proposal. From his comments on 9 February 1982: "JPL is the repository of most of the technical expertise and programme management for our planetary programme. It is an immense national asset. The last thing I want to do is disband that. I think JPL will continue as the centre of this nation's exploration into the foreseeable future." Beggs acknowledged that some decrease in the level of activity would occur and foresaw JPL taking up the slack with Department of Defense



The Infrared Astronomical Satellite as it was being prepared for magnetic testing at ESTEC in the Netherlands.

NIVR

The near-Earth asteroid 1982 DB was discovered (see news story below) by Eleanor Helin while she was photographing the split comet du Toit-Hartley, one component of which (labelled "A") is seen in the photograph. The telescope was guided on the comet, leaving the asteroid (labelled "B") and stellar background to show up as trails.

NASA/JPL

work, up to a level of a quarter or a third of the total Laboratory effort.

Similar sentiments on the future activity of JPL were voiced by Robert J. Parks, Associate Director for Space Science and Exploration at JPL. In an interview published in the 26 February 1982 issue of the "JPL Universe" Parks said: "We believe that out of all of this we will maintain an active and challenging programme. Our projects will be smaller in size, but will continue to be challenging in technology and implementation and will be scientifically rewarding. Although there will be a decrease in the total NASA work we will do, that will be apparently offset by the anticipated growth in DoD work." Parks went on to point out that the Laboratory currently had the Voyager and Galileo projects, a healthy Deep Space Network, smaller projects such as the Infrared Astronomical Satellite (IRAS) and the Solar Mesospheric Explorer (SME), and was continuing to develop low-cost planetary proposals within the context of its Mariner Mark II project.

ASTEROID APPROACHES EARTH

On the evening of 27 February 1982, Eleanor F. Helin of JPL discovered an asteroid while she was photographing the comet du Toit-Hartley with the 48-inch Schmidt at Mt. Pålomar. The object has received the designation 1982 DB and a preliminary orbit has been computed for it by Brian Marsden of the Minor Planet Center. At closest approach to the Sun it is inside the orbit of the Earth, while it goes out beyond the orbit of Mars at the aphelion point of its 1.8 year orbit about the Sun.

The asteroid had a very close approach to Earth on 24 January 1982 when it was only 4.1 million km from us. However, it would have been difficult to observe at that time since it was quite close to the Sun, in degrees.

In addition to the slight, retrospective shiver which this relatively near miss might induce, 1982 DB is of potential scientific importance. Drs. David Bender and Neal Hulkower of JPL's Mission Design Section have conducted a preliminary analysis of 1982 DB as a candidate for spacecraft rendezvous and have concluded that it is the most accessible of the known asteroids. In this role it replaces the asteroid Anteros which has heretofore figured prominently in mission-design scenarios created at the Laboratory.

LOW-COST PLANETARY MISSIONS

The Mariner Mark II project (MMII) was initiated recently at JPL in order to develop a set of planetary missions which will allow continued exploration of the Solar System under very tight budget constraints.

The central idea is to design the mission "set" so that a relatively constant yearly expenditure suffices. The fiscal target is a cost of about $100 million (1982 dollars) per year for the funding of four to five missions launched in the 1989 to 1998 period. Focussed science, reduced complexity, and maximised inheritance (hence the Mariner Mark II designation) are key to achieving the MMII goals.

The mission set for MMII is still under study but several mission types are being considered:

1. Comet rendezvous
2. Comet intercept/sample return
3. Asteroid rendezvous (near Earth and main belt)
4. Mars orbiter
5. Titan flyby/Titan probe
6. Saturn orbiter/Titan mapper

The indicated launch vehicle for these missions is the STS/IUS 2-stage with or without the STAR-48 kick stage.

DIRECTOR LEAVES

Dr. Bruce Murray, Director of JPL, announced as part of his seventh annual "State of the Lab" address on 2 April that he will be stepping down from the Directorship later this year. He has held the post since April 1976, succeeding Dr. William Pickering. Dr. Murray indicated that he would engage in some long-overdue travel with his wife Suzanne and planned to do some writing.

This view from Shuttle Orbiter *Columbia* was taken on 14 November 1981 using the Shuttle Imaging Radar-A (SIR-A) system. It shows a 50×100 km area of southern Greece. The arrow indicates the city of Corinth, which appears as a small white patch.

NASA/JPL

Dr. Murray assumed the job of JPL Director with the understanding that he would serve for five to ten years, and he observed that this committment has been fulfilled. He envisages that "the JPL of 1990 can very easily be the best place in the entire world for engineers and Earth and space scientists to practice their skills" and feels that it is important that the (new) JPL director be able to commit himself to leading the Laboratory through the remainder of this decade.

The identity of the new Director and the date of transition have not been announced.

SHUTTLE EXPERIMENTS

Two of the seven experiments aboard the Space Shuttle *Columbia* were designed by JPL for the scientific payload flown 12-14 November 1981.

The Shuttle Imaging Radar-A (SIR-A) represents a natural outgrowth from a JPL technological base for synthetic aperture radars (SAR), one of which was employed on the 1978 Seasat oceanographic satellite. The SAR technology also played a prominent role in the design of the Venus Orbiting Imaging Radar mission (VOIR), now cancelled due to budgetary constraints.

SIR-A obtained eight hours of data covering ten million square kilometers of Earth, including a 45 minute swath from Spain, through the Mediterranean, and out to India and Australia.

The primary advantage of SAR observations over more conventional optical images is that the SAR supplies its own microwave illumination and is not limited by the presence of clouds or the lack of sunlight. After processing, the SIR-A system can yield a spatial resolution of 40 m. This resolution is obtained using an antenna which measures 9.35 by 2.0 m.

The failure of a fuel cell onboard *Columbia* necessitated an early return to Earth and a resultant disruption of the original mission design for the SIR-A experiment. However, using a microcomputer equipped with an advanced graphical software package, Henry Harris (team leader) and Joan Pojman of JPL rapidly redesigned the experimental procedures, and a new set of commands was sent to the crew in time to successfully obtain the data.

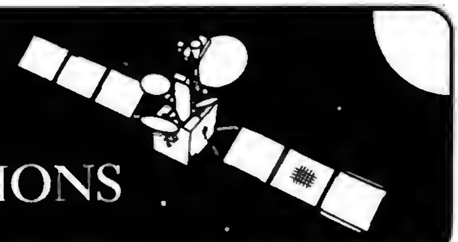
The Principal Investigator for the SIR-A experiment was Charles Elachi of JPL.

The second experiment, the Shuttle Multispectral Infrared Radiometer (SMIRR), was flown in order to investigate Earth resources.

The spectral reflectance of rocks and soil on the surface of the Earth permits inferences to be made concerning the composition of surface materials or possible petroleum deposits below the surface. The system consists of a 17.8 cm telescope (derived from a telescope flown on the 1973 Mariner 10 Mission to Venus and Mercury), filters, detectors, and other supporting equipment. Ten bands within the 1.0 to 2.5 micron portion of the infrared were tested for effectiveness in providing clues to surface composition. Since the SMIRR is not an imaging device, two cameras (one colour and one black and white) were aligned with the SMIRR telescope to provide images which can be correlated with the SMIRR data.

Initial results obtained from analysis of the data from this instrument were announced at a meeting of the American Society of Photogrammetry in Denver, Colorado in March 1982. In one case the SMIRR appears to have surpassed normal field techniques in the ability to differentiate between minerals! The Principal Investigator was Dr. Alexander Goetz of JPL.

SPACE COMMUNICATIONS



INTELSAT VI CONTRACT

The largest ever satellite contract has been awarded to an international team led by Hughes Aircraft Company with British Aerospace as principal member. The contract, awarded by Intelsat, is for five spacecraft. Intelsat also has options for 11 additional spacecraft that could eventually raise the programme value to $1600 million.

Intelsat, a consortium of 106 countries, provides international communications traffic carried by satellite. All international television and about two-thirds of intercontinental telephone services are now carried by 14 Intelsat satellites orbiting 22,300 miles high.

The spacecraft will be 39 ft tall and 12 ft in diameter. In orbit, each will weigh 4000 lb. Their solar panels will generate 2,200 watts of electrical power and each satellite will provide 10 years of communication service.

Each spacecraft will be able to carry 33,000 two-way telephone calls and four television channels – double the capability of the current Intelsat spacecraft. Intelsat plans to launch the new craft on Space Shuttle and Ariane.

ANIK D DELIVERED

The first of two Anik D communications satellites were delivered to Telesat Canada in mid-May by Spar Aerospace marking the first time that a Canadian communications satellite has been built by a Canadian industrial prime contractor.

The Anik D is the fifth in a series of Canadian communications satellites that saw its first launch a decade ago.

Anik D is a 24 channel, 6/4 GHz satellite to be used for TV distribution, telephony and data transmission. These spacecraft will have a longer life and twice the traffic-carrying capacity of the Anik A series they replace. This first satellite was scheduled to be launched by NASA for Telesat from Cape Canaveral on 12 August.

The delivery ceremony was held at the David Florida Laboratory, the Canadian Covernment's Department of Communications' spacecraft environmental test and integration facility. Expansion in 1980 made the facility compatible with spacecraft designed for launch by the Space Shuttle or Ariane vehicles. Telesat Canada is a Canadian company that owns and operates communications satellites for Canadian domestic communications.

AUSTRALIAN SATELLITES

AUSSAT Proprietary Ltd., Australia's national satellite company, has signed an agreement with Hughes Communications International to build Australia's first communication satellite system. The three-satellite system, called Aussat, will provide a variety of communication services, including the first television transmissions to many of the communities and homesteads in the country's remote outback regions. The $175 million contract includes the satellites, and satellite control facilities at Sydney and Perth.

The first satellite is scheduled to be launched in mid-1985, with the second about four months later. Each satellite is warranted for seven years.

Ian Sinclair, Australia's Minister for Communications, called the satellite system a "historic new step in communications and broadcasting," adding that Aussat will have "as profound an effect on Australian life" as did the country's first overland telegraph line in 1872. Australia joins a growing list of countries and American businesses that have selected the Hughes spin-stabilized satellite, including: Telesat Canada, Perumtel of Indonesia, Spar Aerospace of Canada, Western Union, Satellite Business Systems, AT & T and Hughes Communications.

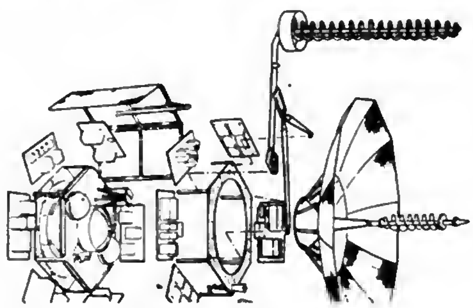
The satellites will be in geostationary orbit above the equator at 156°E, 160°E, and 164°E longitude. The satellites' multiple beam patterns will cover the entire continent. Separately, the system will carry telecommunications to Papua New Cuinea and the offshore islands.

High-quality television relays between major cities, digital data transmissions and telephony will be carried over the traffic control services and maritime radio coverage.

Approximately 70 per cent of the world's current commercial communication satellites have been built by Hughes, which developed and built the first geosynchronous satellite, Syncom, in 1963. Since Syncom, Hughes-built satellites have performed their missions for a cumulative total of more than 250 years.

NEW FLTSATCOM CONTRACT

A $47 million contract for long lead procurement parts for the Fleet Satellite Communications System (FLTSATCOM) Flights 6, 7 and 8 has been awarded to TRW Electronics and Defense of Redondo Beach in California. The contract, awarded by the Air Force Systems Command's Space Division will insure the launch of Flight 6 in early 1985.



The FLTSATCOM system provides worldwide, high priority ultra high frequency (UHF) communications for naval aircraft, ships, submarines, ground stations, aircraft of the Strategic Air Command and the Presidential command networks. Four FLTSATCOM spacecraft have been placed into geosynchronous Equatorial orbit, providing global coverage. These have been working flawlessly since the first launch in 1978. A fifth spacecraft, launched in August 1981 as an orbital spare, suffered damage during launch which prevented it from becoming operational.

LEASAT COMMUNICATIONS SATELLITE

Construction work has resumed on the Leasat project, a US Navy communications satellite now expected to be launched by the Shuttle in 1984.

The Navy awarded the contract to Hughes Communications Services in 1978 for five satellites (one spare) with launches beginning this year. But delays in the Shuttle programme introduced so much uncertainty that construction work on the satellite was halted and all the hardware placed into protected storage.

The Marisat and Fltsatcom satellites have continued to provide services for longer than expected and only now has work been restarted on Leasat.

Leasat will weigh 2,900 lb (1318 kg) in geostationary orbit, with a diameter of 14 ft (4.3 m) and a height of 20 ft (6.1 m). It is the first of the "widebody" satellites designed for launch only by the Shuttle.

MILSTAR STUDIES UNDERWAY

A $4 million concept validation contract for the new MILSTAR satellite communication system has been awarded to the team of TRW Electronics and Defense and Hughes Space and Communications Group by the Air Force Systems Command's Space Division in Los Angeles. The team was one of three awarded contracts to study the concept validation for the space segment of the new communications system.

The team will provide conceptual plans and designs for the development of the MILSTAR satellite segment and ground-based command and control facilities. MILSTAR, the next generation military satellite communications system, will provide more reliable and effective communications to serve both strategic and tactical forces.

An engineering development contract for the space and ground control segment of the system will be awarded in early 1983.

TV TRANSMISSION RECORD

A record number of international satellite TV transmissions over a one week period were made around the globe in early April. A total of 572 transmissions were carried between 12 and 18 April via the Intelsat system of satellite (which account for nearly all of the world's oceanic TV broadcasts).

Dan James, chief of Intelsat TV Service operations with Washington, D.C., said that the previous weekly record of 540 transmissions had been established in January 1981 when the US Presidential Inauguration and the Iranian hostage release occured simultaneously. "While it was difficult to pinpoint a reason for last week's record, the Falkland Islands crisis had been a major contributor," Mr. James said.

"The fact is that the basic threshold of international satellite television usage is rising all the time. We now regularly exceed the levels of transmission set by such world events as the Moscow Olympics a couple of years ago," Mr. James said.

TDMA CONTRACT

Intelsat has awarded a $14.3 million contract to the Nippon Electric Company of Japan, for the supply of TDMA Reference and Monitor Station equipment for use in its international satellite communications network.

The NEC contract calls for eight sets of TDMA (Time Division Multiple Access) equipment which, when located in Earth stations selected to provide reference station services around the world, will enable Intelsat to introduce digital operations into its system.

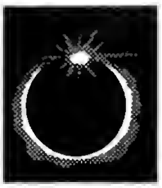
The contract also includes options for an additional 12 sets of equipment. If these are exercised, the total value of the contract would exceed $30 million.

EARTH STATION FOR NEPAL

Nepal's first satellite Earth station was shipped out to Kathmandu last May by Marconi Communications of Chelmsford.

Scheduled to begin operating in September, the Standard B terminal is being built as a "turn-key" project, which means that the Nepal Telecommunications Corporation will take it over complete, the manufacturers having carried out the project from the start. This includes preparation of the site, civil engineering, design, manufacture, installation and commissioning of the equipment.

The microwave line-of-sight link that joins the Earth station to the Nepal trunk telecommunications network some 10 km away beyond a mountain ridge is also being supplied.



SPACELAB FOLLOW-ON

The European Space Agency's Spacelab Development Programme is gradually drawing towards its conclusion: the flight unit, in its first configuration, was delivered to NASA at the end of 1981, and the second configuration was due to be delivered this summer. Integration work is proceeding according to plan for a launch in September 1983.

ESA's activities in this field will not, however, end with the Spacelab 1 mission. It is about to embark on a new related programme: Spacelab Follow-on. On 15 April, the contributions of ESA Member States participating in this new programme reached 80.8 per cent of the financial envelope of 155.9 million Accounting Units (mid-1980 prices), thus enabling work to start immediately.

There are three elements to this new programme, the most important of which is the development of a European Retrievable Carrier (EURECA) to be launched and retrieved by the Space Shuttle. This programme element also includes the development of a core payload for the first mission, mainly oriented towards Microgravity research with particular emphasis on Material and Life Sciences, as well as the first flight, scheduled for end-1986.

EURECA is a re-usable payload carrier designed to suit European user requirements. With a payload mass of up to 1500 kg, it can stay for six months or more in orbit and will provide essential services for its payload, including high electrical power and heat rejection capability. A basic performance characteristic is its low gravity disturbance level which is an essential feature for Microgravity research. After deployment into space by the Shuttle, an on-board propulsion unit will propel the carrier into a higher orbit where the drag on its large solar arrays will be low. There the payload will be switched on and operated by remote control. Although the experiments will be highly automated, they will nevertheless be monitored from the ground. At the end of its mission, EURECA will return to low orbit where it will be recovered by the Shuttle Orbiter and brought back to Earth together with its payload equipment and processed material samples, for refurbishment for its next mission.

EURECA can thus be described as a re-usable 'free flyer' which will enable longer duration missions to be carried out in an economic way.

The two other elements of the Spacelab Follow-on Programme include improvements to be made to Spacelab itself and preparatory studies for future space platform elements. However, parts of these two are blocked for the time being pending NASA decisions on Shuttle improvements and due also to funding limitations.

ROCKET EXPERIMENT FAILS

Scientists from the Canadian Research Council and American universities were disappointed on 15 March 1982 when the rocket carrying the "Waterhole 2" payload failed shortly after launch from Churchill in Manitoba, writes Joel Powell. The 180 kg payload containing water was intended to be detonated at about 250 km high amid an auroral display to produce a plasma depletion which would produce a 50 km hole in the aurora. The first Waterhole experiment, launched on 6 April 1980 (with a Nike-Black Brant VIII rocket), surprisingly quenched a large portion of the target aurora and dimmed other auroral arcs extending to Siberia.

Waterhole 2 was the first launch for the new Black Brant IX rocket (Terrier booster and Black Brant V upper stage), a derivative of the three stage Black Brant X "Nihka", first tested in August 1981.

X-RAY OBSERVATORY MIRRORS

Twin $1 million contracts have been awarded to two optical companies to build precision mirrors representative of those to be flown on NASA's Advanced X-Ray Astrophysics Facility (AXAF), an orbiting X-ray observatory proposed for launch later in the decade.

The double contract award, announced on 6 April, assigns responsibility for parallel but independent work toward the building of these test mirrors (not intended to be flown in space) to the Itek and Perkin-Elmer corporations. Each of the contracts is two years in duration.

At the end of the contract period, the two companies will be expected to present their individual approaches to the grinding and polishing of the actual mirror which will be built for the observatory in the late 1980's.

The test mirrors will be smaller than the mirror to be flown in space. According to Carroll Dailey, the study manager of the Marshall Space Flight Center's AXAF activity, "The purpose of the test mirrors is to allow NASA to evaluate the ability of these contractors to achieve the level of performance we desire. We're seeking a greater precision than previously achieved in X-ray optical systems."

Proposed for launch in 1989 or 1990, the observatory would be technologically superior to any X-ray facility previously sent into space. Weighing 11 tons and measuring 14 by 43 feet, it would be carried by the Space Shuttle and placed in an orbit 300 miles above the Earth for operation over a lifetime of about 15 years. The observatory is expected to view X-ray sources toward the very edge of the observable Universe.

SHUTTLE CONFERENCE

Nearly 500 delegates gathered last May to attend the 1982 Space Shuttle Symposium, held in Phoenix, Arizona, writes Desmond Welch. Highlighting the conference, the largest and most comprehensive on the Shuttle ever held in the US, were

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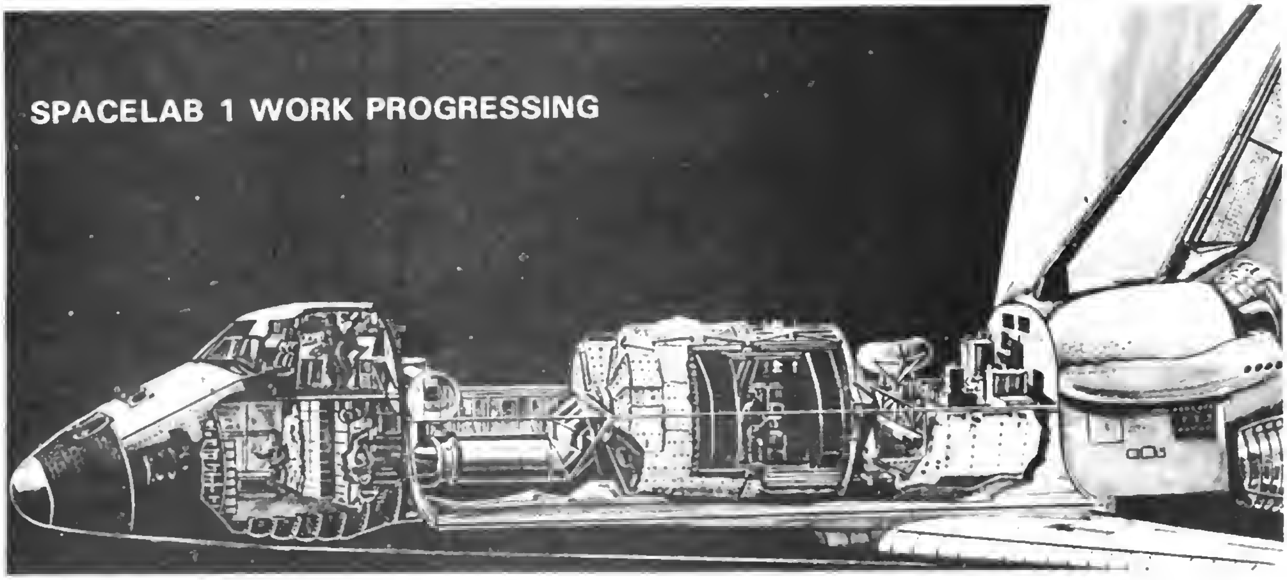
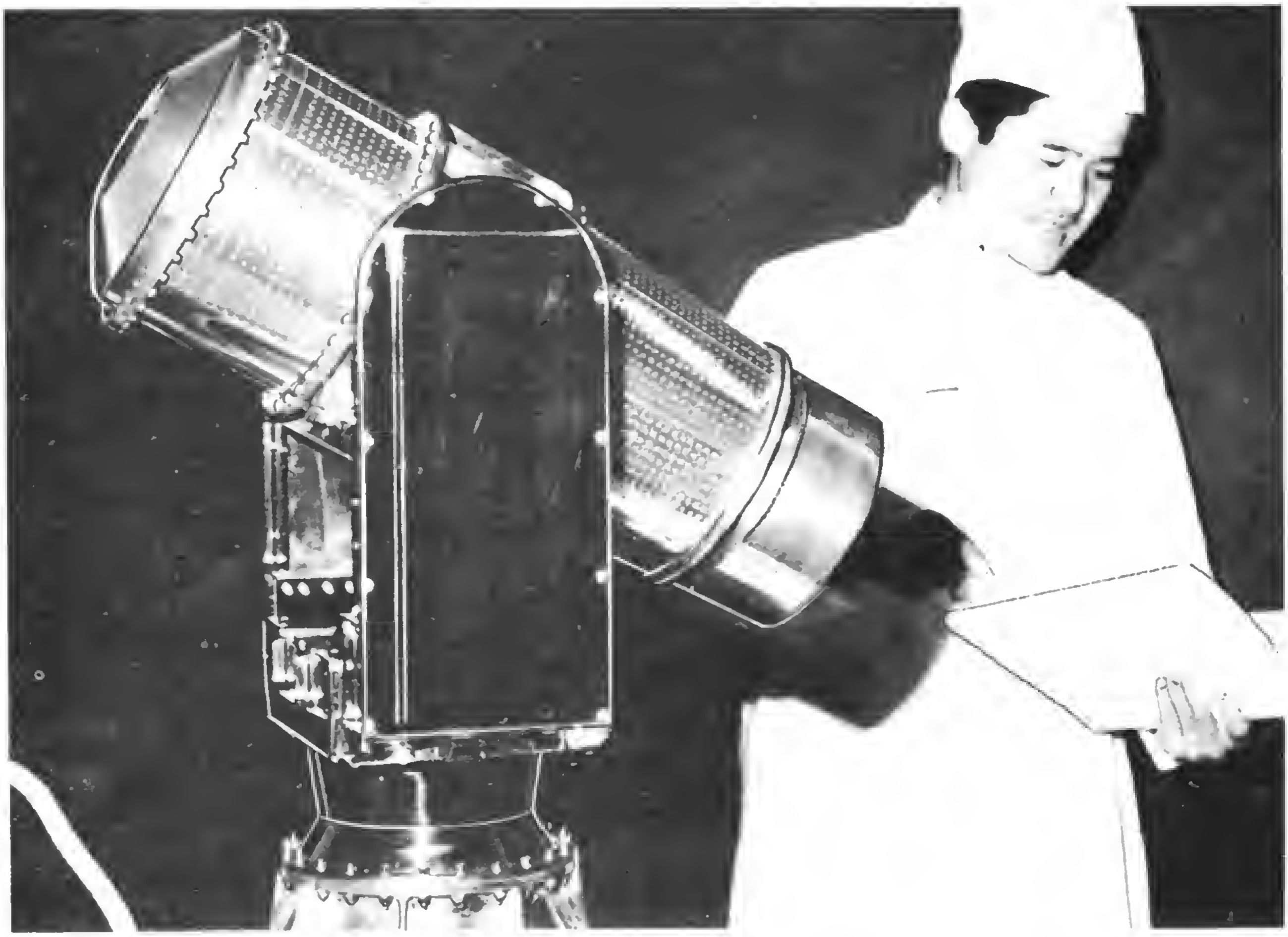
SPACELAB 1 WORK PROGRESSING



Work on the Spacelab 1 flight unit is progressing at the Kennedy Space Center toward the launch date of September next year aboard Shuttle Orbiter *Challenger*. The Spacelab structure was delivered to KSC last December and transfered to NASA's Operations and Check-out Building. The formal handing-over was performed in February and in May the European experiments for SL-1 were delivered for integration with the rest of the hardware. *Above:* artist's impression of the Spacelab 1 configuration; *below:* integration of part of the SEPAC (Space Experiments Using Particle Accelerators) experiment. The unit seen here is a camera to record what happens when electrons are pumped into the space environment. The experiment is a joint venture between the Institute of Space and Aeronautical Science in Tokyo and NASA's Marshall Space Flight Center.



Jack Lousma and Gordon Fullerton, crew of *Columbia*'s third flight last March.

Fourteen speakers, all but one from NASA, took part in almost 20 sessions on Shuttle-related topics.

Guest speaker Robert McCall, renowned space artist, opened the conference with a discussion of man's greatest achievements, illustrating his points with many of his own photographs and paintings, including his well-known artwork for the film of *2001: A Space Odyssey*. Dr. Max Faget, chief of Engineering and Development at the Johnson Space Center during the 1960s and early 1970s, and holder of the patent on the Orbiter, delivered the keynote address, "Overview of Space Shuttle Design Features".

The STS-3 astronauts, were greeted with a standing ovation. They described themselves as "just a couple of guys who took eight days to get from Florida to New Mexico." They briefly recounted their adventure in space, then narrated a film of the mission. After noting that STS-3 had been his first space flight, Gordon Fullerton confessed dryly that, shortly after launch, "while riding on that noisy, vibrating rocket, I thought back to the day that I volunteered to do that."

The Shuttle's thermal tiles were discussed in depth by Robert L. Potts, manager of the Orbital Reusable Surface Insulation System at JSC. Despite the controversy surrounding their reliability, the tiles are far more tolerant to damage than had been predicted. It also appeared that the tiles and Orbiter structure have been running at considerably cooler temperatures than anticipated, both during and after reentry.

John Kiker, the NASA engineer who invented the piggyback system for testing and transporting the Orbiter, told of the inspiration that led him to propose his innovative technique. As a model aircraft enthusiast, he once saw an old picture of a glider riding up to altitude on top of a radio-controlled aircraft. He tested his theory with his own home-built models and proved that, despite some stability problems with his model Orbiter, the system was feasible.

William Brasher, from the Primary Propulsion Branch at JSC, enumerated the advantages of the Shuttle's main engines over those of the Saturn 5. The components are bolted together, as opposed to being welded, to allow easy maintenance and replacement of engine parts. Although the specific impulse improvement over the Saturn upper stage engine (the liquid hydrogen/liquid oxygen J-2) is only about 30 s, each second of specific impulse gain represents an increase of about 1,100 lb (500 kg) of payload.

It was pointed out by Ivy Hooks, manager of JSC's Shuttle data-base office, that spin-off from space programmes has benefited industry by $64 for every $1 spent on NASA.

KRAFT TO LEAVE NASA

Dr. Christopher C. Kraft, Director of the Johnson Space Center in Houston, will leave NASA following the fifth space flight of the Space Shuttle (scheduled for November).

Kraft is a charter member of the US space programme. He was with the National Advisory Committee for Aeronautics at the Langley Aeronautical Laboratory from 1945 until Langley became a part of NASA when the agency was established on 1 October 1958. At that time Kraft became a member of the Space Task Group which managed Project Mercury.

The Task Group became the nucleus of the Manned Spacecraft Center, which became the Johnson Space Center in 1973. Kraft was a principal architect of many of the basic mission and flight control techniques used in all of the US manned space flights. He was flight director for all the Mercury space missions and many of the Gemini manned space flights. He directed the design and operations of the Mission Control Center in Houston from which all of the US manned missions have been controlled since Gemini 4 in 1965.

Kraft has been director of the Johnson Space Center since January 1972. He succeeded Dr. Robert Gilruth, the first director of the centre and a man Kraft considers his mentor and the father of the US manned space flight programme.

NASA STS CHANGES

NASA's Offices of Space Transportation Systems and Space Transportation Operations were merged on 15 May. Maj. Gen. James A. Abrahamson (USAF) heads the new Office of Space Transportation Systems. The combined office was responsible for the fourth and final development flight of the Space Shuttle and for the operational flights, as well as further Shuttle procurement and expendable launch vehicles.

Dr. Stanley I. Weiss, who had headed the Space Transportation Operations became NASA's Chief Engineer, succeeding Dr. Walter C. Williams, who plans to retire later this year. Because of the importance of this function and the preparation for the STS-4 launch, this change required a short period of transition.

The Chief Engineer's office took on added responsibilities for institutional safety and for reliability and quality assurance. Williams, who had been Chief Engineer since 1976, continues to consult on Shuttle systems engineering and safety.

Gerald D. Griffin, previously Deputy Director of the Kennedy Space Center and the Dryden Flight Research Center, returned to NASA. Initially, he is working with Abrahamson on Shuttle operational planning. Later this year it is planned that he will move to Houston as Director of the Johnson Space Center. He will succeed Dr. Christopher C. Kraft, Director since 1972, who has announced his plan to leave NASA, following the fifth Space Shuttle flight (see previous item).

In announcing the organisational and personnel changes, NASA Administrator Beggs said, "As we approach the end of the Shuttle developmental flights and the beginning of the initial operations, we want to prepare the organisation for operations. During this same time, planned retirements give us the opportunity to name several new key managers for the period ahead. These changes will give us an efficient organisation with strong leadership for the future."

OCEANS ON VENUS?

The searingly hot planet Venus at one time had sufficient water to have oceans 30 per cent or more the size of those on Earth, according to Pioneer-Venus investigator Dr. Thomas Donahue. He initially indicated the potential for a Venusian ocean at the November 1981 Venus Conference at Palo Alto in California.

At that time Donahue and colleagues had begun piecing together clues originally obtained during the descent of the Pioneer Venus large probe into the planet's lower atmosphere. The port to the probe's mass spectrometer became coated with sulphuric acid droplets from the clouds and reliable measurements were not expected to result while the port was clogged.

At the Pioneer Venus conference, however, Donahue and fellow investigators began to discuss the possibility of determining the concentration ratio of deuterium (heavy hydrogen) to hydrogen with the clogged instrument. The sulphuric acid blocking the instrument port would, it was hoped, contain sufficient traces of Venusian water to permit determination of the current ratio of deuterium to hydrogen. Because of the different rates of the escape of light hydrogen (H) and heavy hydrogen (D) over geologic time, determination of the current deuterium/hydrogen ratio would provide the atmospheric scientists with indications of whether Venus has always lacked

Continued on p. 352

THE ASTRONAUTS OF STS-5

Pilots for the fifth Shuttle mission. *Left:* Vance Brand (Cdr.); *right:* Bob Overmyer.
NASA

Vance DeVoe Brand

Commander for the first operational mission of the Shuttle was civilian astronaut Vance Brand. Born in Longmont, Colorado on 9 May 1931, he flew as a fighter pilot with the Navy before working with the Lockheed Aircraft Corporation between 1960 and 1966. He graduated from the USN Test Pilot School in 1963 and worked on the F-104 "Starfighter" development programme.

Brand was selected as one of the 19 Group 5 astronauts in April 1966 and concentrated on the Apollo Command Module. He was the backup CM Pilot for Apollo 15 and should have flown the (cancelled) Apollo 18 lunar mission. He served as backup commander for Skylab's 3 and 4, as well as on the stand-by rescue crew. In January 1973 he was named as CMP for the Apollo-Soyuz mission flown in July 1975. He then moved on to Shuttle development work and was originally announced as Commander of STS-4 with Fullerton as his pilot.

Robert Franklyn Overmyer

Overmyer was born on 14 July 1936 at Lorain in Ohio. He joined the US Marine Corps on active duty in 1958 and in August 1965 he entered the USAF Aerospace Research Pilot School at Edwards Air Force Base. Upon graduation, he joined the second group of Manned Orbiting Laboratory astronauts and transferred to NASA in August 1969 as part of the Group 7 ex-MOL men.

Overmyer was part of the support crews for Apollo 17 and Apollo-Soyuz and in 1976 he moved on to the Shuttle programme. He flew as the prime T-38 chase pilot for the *Enterprise* drop tests of 12 August and 23 September 1977. He replaced Fullerton for the STS-4 mission when Haise left NASA in June 1979; the two-man crew later moving to STS-5.

William Benjamin Lenoir

In conjunction with Joe Allen, Lenoir will be the first of the NASA Group 6 astronauts, selected in mid-1967, to fly a space mission. He was born in Miami on 14 March 1939. Lenoir served as backup science pilot on Skylabs 3 and 4; in 1974 he was assigned to Shuttle development work, concentrating on payload support crew stations and displays for the physical sciences. In 1979 he was assigned to support development of Shuttle payload deployment and retrieval.

Joseph Percival Allen IV

Allen was born on 27 June 1937 at Crawfordsville in Indianna. He acted as a support crew member and mission scientist for Apollo 15; in 1973 he was granted a leave of absence and served on the President's Council on International Economic Policy. He began Shuttle work in 1975 with special reference to Spacelab and payload support crew stations, controls and displays for the physical sciences. He acted as an STS-1 support crew member and Capcom.

THE ASTRONAUTS OF STS-4

Thomas Kenneth Mattingly II

Ken Mattingly was born in Chicago, Illinois on 17 March 1936. He was selected as a NASA Group 5 astronaut in April 1966 and was thus available for the later Apollo lunar flights. He became the astronaut representative for the development of the Apollo spacesuit and backpack for EVA operations, and served on the support crews for Apollos 8 and 11.

Mattingly was assigned as Command Module Pilot of the third manned lunar mission, Apollo 13, but had to step down from the crew (John Swigert took his place) just three days before launch because of his exposure to German measles. He flew as CMP on John Young's Apollo 16 crew in April 1972 and became the second man to conduct an EVA in deep space.

From January 1973, Mattingly was assigned to Shuttle duties: Chief of Shuttle support, Astronaut Office; Technical Assistant to Manager of Orbital Flight Test Programmes (March 1978 -December 1979); Head of Astronaut Office ascent/entry group (December 1979–April 1981). Between April and November 1981 he served as backup Commander for STS-2, and then held the same position for STS-3. He was named as Commander of the fourth Shuttle orbital mission last December.

Henry Warren Hartsfield, Jr.

Henry "Hank" Hartsfield was born on 21 November 1933 in Birmingham, Alabama. He served as an instructor at the USAF Test Pilot School at Edwards Air Force Base in California before being selected as a Group 2 USAF Manned Orbiting Laboratory astronaut in June 1966.

After the cancellation of MOL in June 1969, Hartsfield became a NASA Group 7 astronaut the following August. He was a support crew member for Apollo 16 and all of the Skylab flights. He was then assigned to Shuttle duties, working on simulations and flight controls systems hardware. By April 1979 he was assigned to Shuttle entry flight control systems and associated interfaces.

Hartsfield served as backup Pilot for STS-2 and 3 (with Mattingly as his Commander) and was named as STS-4 pilot last December. He was the fourth Group 7 astronaut to fly, and the 48th American.

D.J. SHAYLER

Continued from p.350
water or whether large amounts of water were present early in the planet's evolution but were subsequently lost.

During the conference, Donahue and others reexamined the data from the probe mass spectrometer to see if they could obtain good deuterium/hydrogen readings. Based on this reexamination, Donahue and his colleagues suggest that the present ratio of deuterium to hydrogen on Venus is on the order of 0.016.

This current ratio, coupled with additional estimates of the original ratio of deuterium to hydrogen on Venus – estimated to be close to that originally on Earth, or 0.00015 – have led Donahue and colleagues to suggest that Venus originally had an ocean which was lost as a result of hydro-dynamic outflowing of hydrogen. Following a large initial outgassing of water from the planet, Donahue suggests that a runaway greenhouse condition ensued that drove hydrogen from the liquid ocean into the atmosphere from which it subsequently left through supersonic hydrodynamic escape. Since this process favours the escape of hydrogen over heavy hydrogen, the deuterium found in the Venus atmosphere today is an observable remnant of the early Venusian ocean.

Donahue and his colleagues suggest that the minimum amount of water lost from Venus was the equivalent of one third of Earth's oceans, although it could have been more.

These findings present intriguing possibilities for future exploration of the cloud-shrouded planet. NASA is currently studying a radar mapping mission (a reduced version of the cancelled VOIR) to Venus which could provide topographical evidence of early river channels and oceans.

BOOSTERS TO FLY AGAIN

Whatever happened to the reusable Solid Rocket Boosters that helped lift the Space Shuttle from its launch pad on the first, second and third flights?

According to NASA's Vince Caruso of the Marshall Space Flight Center, all six of the boosters are being prepared to fly again. Because refurbishment processing times differ for the various components of the boosters, some parts will be reused earlier than others.

The first pieces of booster hardware to demonstrate their reusable characteristics will be the parachutes used on the first mission. The 'chutes have been cleaned, checked for any damage and repacked. They are scheduled for use again on STS-5.

"Other booster components from STS-1 will be used on successive Shuttle flights," said Caruso, who heads the production management and planning office for the Marshall Center's Solid Rocket Booster Project. "The forward skirts and frustums of those boosters will go on STS-6, the aft skirts on STS-7 and the motor segments will fly on STS-8," he said. "Reuse of the boosters from flights two and three will follow the same pattern; the parachutes from STS-2 will fly again on STS-6, and so on. Right now we are sending some hardware back to the manufacturers to have the work done, but as we become operational the majority of the work will be done at the Kennedy Space Center by United Space Boosters Inc., under the direction of Marshall's Resident Office there," Caruso said. The solid motor cases, however, will continue to be returned to the manufacturer to be refilled with solid propellant.

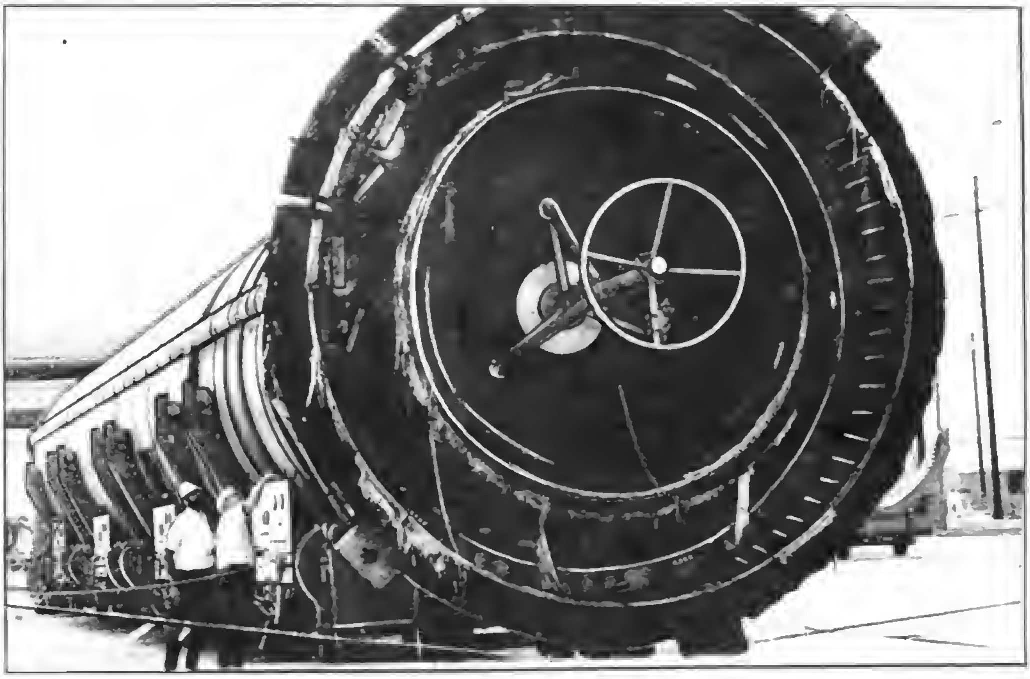
"We expect to reuse the parachute systems up to 10 times," said Caruso, "and the rest of the booster systems about 20 times."

ARIANE RECOVERY

The launch of Ariane L6 (two others were scheduled for later this year until problems arose with the L5 payloads in April) will see the first attempt to recover the first stage so that its engines can be refurbished for later flights.

The Ariane first stage has a diameter of 12.5 ft (3.8 m) and stands 60.4 ft (18.4 m) high. It contains two steel tanks which at launch hold 147.5 tonnes of fuel to feed the four Viking motors which deliver 245 tonnes of thrust. If the motors were re-used it could save $2 million a launch.

The aim is to slow the 350 mph (560 kph) descent into the Atlantic so that a ship can scoop the stage aboard. The gradual deceleration involves the use of seven parachutes released in sequence by barometric devices coupled to pyrotechnics. Ariane first stage separates at a height of 30 miles (40 km) but



One of the STS-3 boosters soon after recovery last March. See news story above, "Boosters to Fly Again".
NASA

the release system marks time until it is 3.7 miles (6 km) above the sea. Then a small auxiliary parachute is drawn out, followed by a larger second, and then an even larger intermediate parachute.

When it is about a mile (1.6 km) above the sea and the descent speed is down to 170 mph (273 kph) the intermediate parachute pulls out the packs of four main 'chutes which finally slow the load ready for landing.

The main parachutes are of an existing type used for heavy freight drops and will be subjected to a loading of 11 tonnes each.

The intermediate 'chute is a version of an existing design used as a braking parachute for Concorde and military aircraft.

Since the parachute system has to withstand the full blast of the second stage rocket motor, ceramic blankets are used for protection of some exposed items. The materials have been tested in an oven for ten seconds at 950°C to simulate engine heat. Straps are made of a new material, Kevlar, which is three times as strong as nylon for the same weight.

EUROPEAN SENSING SATELLITE

The European Space Agency is about to embark on a major new programme: the first ESA Remote Sensing Satellite Programme, known as ERS 1.

On 15 May 1982, contributions from participating states reached the level of the financial envelope laid down for starting the system definition phase (Phase B) of the ERS 1 programme. The final decision to proceed with phase C/D (hardware development) will be taken at the end of 1983.

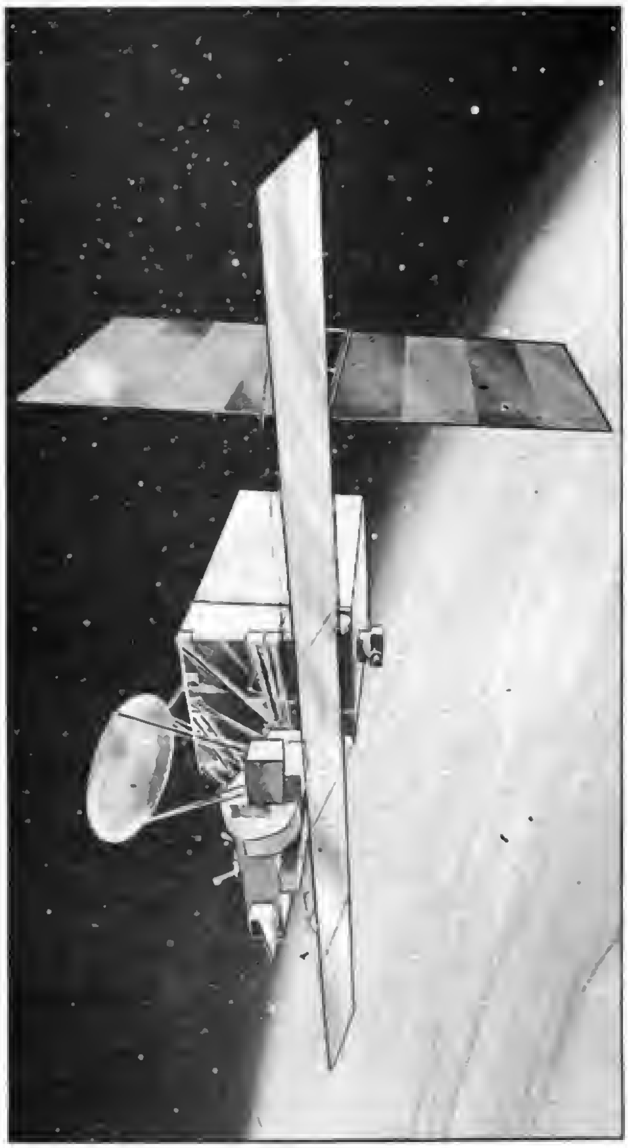
The main objective of the ERS 1 programme is to give Europe the ability to take part in both the management of the Earth's resources and the monitoring of its environment. ERS 1 aims, in particular, at establishing, developing and exploiting the coastal, ocean and ice applications of remote sensing data. The satellite's nominal payload consists of:

1. Active microwave instrumentation (AMI) combining the functions of a synthetic aperture radar (SAR), a wave scatterometer and a wind scatterometer, with the aim of measuring wind fields and the wave image spectrum, and of taking all-weather images of coastal zones, open oceans, ice areas and over land;
2. Radar altimeter (RA) with the aim of measuring significant wave-height and providing measurements over ice and of major ocean currents;
3. Laser retroflectors for accurate tracking from the ground;
4. The Along Track Scanning Radiometer (ATSR), an additional package, to be provided and funded by the UK and resulting from an announcement of opportunity to the scientific community. This is a 3-channel infrared radiometer for accurate sea-surface temperature measurements.

The above payload will be carried on a platform based on another model of the Multi-mission Platform developed in the framework of the French SPOT programme.

ERS 1 will permit worldwide coverage. Direct transmission to ground stations will be provided and onboard recorders will give access to data from any part of the world, except for the SAR, for which, due to the high bit-rate, only real-time transmission is possible. The ground segment will be dimensioned in such a way that certain ERS 1 data will be processed and delivered in near real-time (3 to 6 hours) to users interested in monitoring rapidly-changing dynamic phenomena.

Apart from the scientific results expected from the mission, which will be of great interest to researchers in physical oceanography, glaciology and climatology, ERS 1 will provide



An artist's impression of the "Coastal/Oceans Monitoring Satellite" when it was under study by British Aerospace on behalf of ESA.

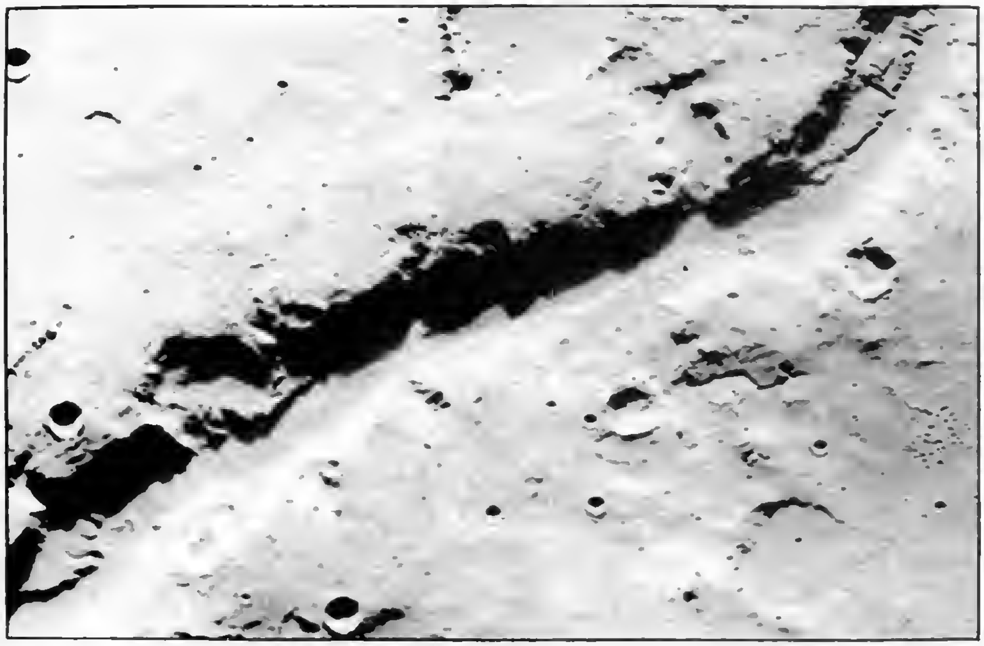
British Aerospace

information that will help to develop commercial applications of immediate practical use. Better short and medium-term weather and ocean condition forecasts can be expected; these are of particular importance not only for shipping but also for the planning and operations of off-shore industrial complexes, such as oil rigs. More accurate sea-surface temperature measurements will be made which will help with the location of fish species living in the vicinity of the sea surface (e.g. tuna) thus improving the management of fish resources. The monitoring of sea-ice and icebergs will also contribute to increasing the safety of shipping and off-shore oil activities in far northern areas.

Another area of interest where ERS 1 is expected to provide useful information, although still in an early stage, is the detection and monitoring of marine surface pollution.

Lastly, high-resolution SAR imagery over land will be used on an all-weather complement to optical data provided by other satellites such as Landsat and SPOT.

Launch into a Sun-synchronous circular orbit at an altitude around 700 km by an Ariane 2 or 3 is planned at the end of



One of the later pictures of Mars taken by Viking Orbiter 1 (see news item below). It shows a canyon - perhaps caused by water erosion - about 16 km wide and 2 km deep cutting across cratered terrain.

1987. Its lifetime is expected to be 3 years. ERS 1 is considered to be both an experimental and a pre-operational system, preparing the way for a fully operational multi-satellite system in the 1990's.

ENGLE TO WASHINGTON

Commander of Shuttle STS 2, astronaut Joe Engle, has recently received a temporary assignment at NASA Headquarters in Washington, writes Dave Shayler. He has been assigned as Deputy Associate Administrator for Manned Spaceflight, reporting directly to Major General James Abrahamson, the director of the Space Shuttle System. His experience and knowledge of space programmes such as the X-15, Apollo and Shuttle will be of use in his new post in which he will contribute expertise in manned capability and integration.

Upon relinquishing his post in the autumn, he is to return to the Johnson Space Center, with possible assignment to the Commander's seat on a Shuttle mission.

VIKING PHOTOGRAPHS

More than 50,000 photographs of Mars, taken by NASA's Viking orbiters from 1976 to 1980, have now been processed at NASA's Jet Propulsion Laboratory in California.

The last photographs taken by the Viking 1 Orbiter were processed in late March this year. The orbiter, one of two that arrived at Mars in 1976, was turned off in August 1980, after it ran out of attitude control gas. Viking 2 Orbiter ceased operations in July 1978. The Viking 1 Lander continues to return scientific data, including photographs, from the Mars surface. The Viking 2 Lander ceased operating in April 1980.

The surviving lander, which is beginning its fourth Martian year of surface and climate studies, is sending back valuable imaging, engineering and meteorological data weekly. Jim Tillman, of the University of Washington, is computer processing this science and engineering data. The lander's radio science investigations also continue.

A programme is currently underway onboard Lander 1 which reconditions each of its four batteries. Barring any critical hardware failures, the lander can continue to operate until December 1994.

Scientists at the Jet Propulsion Laboratory and other research centers continue to study the Mars imaging data. Work at JPL includes mosaicing the orbiter images, and the study of channels, volcanoes and tectonic features on the Martian surface. Results, reported from analysis of photographs and other data, indicate strong evidence that surface water exists on Mars in the form of ground ice. Also, the layers in the North polar cap appear to hold the key to understanding the climate changes on that planet as they do on Earth. Finally, the seasonal nature of Mars can be noted in cloud forms and motion, volatile migration from pole to pole, frost accumulation and variations in temperature and pressure.

NEW PIONEER CONTRACT

A $1,850,000 contract for continuing support of NASA's several interplanetary Pioneer spacecraft was awarded in April by NASA's Ames Research Center to the Bendix Field Engineering Corporation's Advanced Data Systems in Sunnyvale, California. The contract provides for operation of the seven Pioneer spacecraft: Pioneers 6-9, Pioneer-Venus Orbiter, and Pioneers 10 and 11.

Pioneers 10 and 11 surveyed Jupiter and Saturn, and both are now on their way out of the Solar System. When Pioneer 10 crosses Neptune's orbit in July 1983 it will be outside the orbit of the farthest planet (since the "outermost planet", Pluto, will be inside Neptune's orbit for the next 17 years). The Pioneer-Venus Orbiter is still taking photos of Venus and measurements of its atmosphere, space environment and interior composition. Pioneers 6 to 9 have been circling the Sun as solar weather stations and returning information for researchers.

The terms of the contract provide for Mission Flight Operations and Data Processing Support Services, which include flight operational control of the seven Pioneer spacecraft, and operation, maintenance and upgrading of the Pioneer Mission flight operation and data processing facilities at NASA's Ames Research Center at Mountain View in California.

SHUTTLE LAUNCH SCHEDULE

NASA has announced an updated launch schedule for the 69 Shuttle flights up to September 1987. Since changes will undoubtedly significantly alter the later launches only the missions up to STS-30 are included in the list here. All of those noted below are from the Kennedy Space Center; the first Vandenberg launch is scheduled for October 1985 (these flights will carry "V" designations, not STS).

Most of the payloads listed here are communications satellites carrying Spinning Solid Upper Stages to take them into geostationary orbit. The military payloads are noted as "DoD". The Orbiters are 099: *Challenger*, 102: *Columbia*, 103: *Discovery* and 104: *Atlantis*.

Even this section of the manifest may be out of date; it appears that Westar 6, here under STS-15, may be launched by Ariane.

Mission	Date	Orbiter	Payload
STS-5	Nov 82	102	SBS-C, Telesat-E
STS-6	Jan 83	099	TDRS-A
STS-7	Apr 83	099	SPAS, Palapa, Telesat-F, OSTA-2
STS-8	Jly 83	099	TDRS-B, Insat 1B
STS-9	Spt 83	102	Spacelab 1
STS-10	Nov 83	099	DoD
STS-11	Dec 83	102	LDEF, SMM repair
STS-12	Jan 84	103	Palapa, TDRS-C
STS-13	Mar 84	099	DoD
STS-14	Apr 84	102	OAST, Telesat 1, RCA-K
STS-15	May 84	103	Westar 6, TDRS-D
STS-16	Jun 84	102	SBS-D, Syncom 4-1
STS-17	Jly 84	099	Spacenet, Westar 7
STS-18	Aug 84	103	Arabsat, Telstar 3C, Syncom 4-2
STS-19	Sep 84	102	Spacelab 3
STS-20	Oct 84	099	OSTA-4, RCA-L, Intelsat 5-1
STS-21	Nov 84	102	Spacelab 2
STS-22	Nov 84	103	DoD
STS-23	Jan 85	099	Space Telescope, LDEF retrieval
STS-24	Jan 85	102	OSS, Arabsat, Intelsat 5-2
STS-25	Feb 85	103	DoD
STS-26	Apr 85	104	Spacelab D-1 (German)
STS-27	Apr 85	102	DoD
STS-28	May 85	099	Telstar 3D, RCA-H, Gstar-C, Syncom 4-3
STS-29	Jne 85	104	OAST, ANSCS-A, Satcol-A, Spacenet-C
STS-30	Jly 85	102	DoD

Payloads other than communications or military:

OSTA, OAST, Space Telescope and OSS are scientific payloads; LDEF is the Long Duration Exposure Facility which will be left in orbit by STS-11 and retrieved a year later by STS-23; "SMM repair" is the capture and repair of the malfunctioning Solar Maximum Mission astronomical satellite; Spacelab is the manned European laboratory.

MICROGRAVITY LAUNCHES

ESA's recently approved Microgravity Research Programme got off to a flying start with the successful launch of two Skylark sounding rockets from the Swedish launch range, Esrange, Kiruna, in the far north of the country.

As part of its new programme, ESA participates in the German (Texus) and Swedish Microgravity Sounding Rocket programmes and, with these first two flights (Texus 5 on 29 April and Texus 6 on 8 May) had a share of the payloads. The six scientific experiments chosen by ESA were all in the field of Material Sciences and were provided by Scientific Institutes in Belgium, France, Germany and the Netherlands. An additional technological experiment, an acoustic mixer designed to produce homogeneous metallic samples in a microgravity environment was also flown.

The user community will benefit from further sounding rocket flight opportunities within the Microgravity Programme in 1983, 1984 and 1985.

The sounding rockets now used in Europe provide some six minutes of microgravity conditions (1/10,000th of the Earth's gravity) and can be used by researchers to carry out precursory experiments for later Spacelab and orbital platform missions.

INDIAN LAUNCHER

The extensive Indian space programme has so far relied on small, expendable national launchers or buying space on other nations' rockets for satellites requiring more exotic orbits. For example, Insat 1 was launched by the US into geostationary orbit to provide communications and meteorological services. By the mid-1980's, however, India hopes to have a booster capable of reaching these more difficult orbits. The Polar Satellite Launch Vehicle (PSLV) is planned to take 1 tonne payloads into 1,000 km Sun-synchronous polar orbits using two liquid propellant engines which will be returned to Earth for re-launch. A larger vehicle for placing 3 tonnes in geostationary orbit is expected for the next decade.

SPACECRAFT CHARGING

Findings on spacecraft electrostatic charging from the Space Test Program's SCATHA (P78-2) satellite launched in 1979 have resulted in new techniques being developed to control this problem, writes Joel Powell. A build-up of a large charge can damage a satellite's delicate electronics.

The highest rate of charging recorded during SCATHA's first year in orbit came on 24 April 1979. Onboard ion and electron beams were able to dissipate only part of the build-up. The Surface Potential Monitor, measuring various material samples for charging resistance, yielded unexpected data on that date. Kapton material charged to a lower level than did Teflon, whereas laboratory tests had indicated the opposite. Quartz fabric charged to a far higher voltage than expected. Further laboratory experiments were able to account for these phenomena, providing engineers with useful guidelines for avoiding the troublesome charging effects in designs for future Clarke orbit spacecraft.

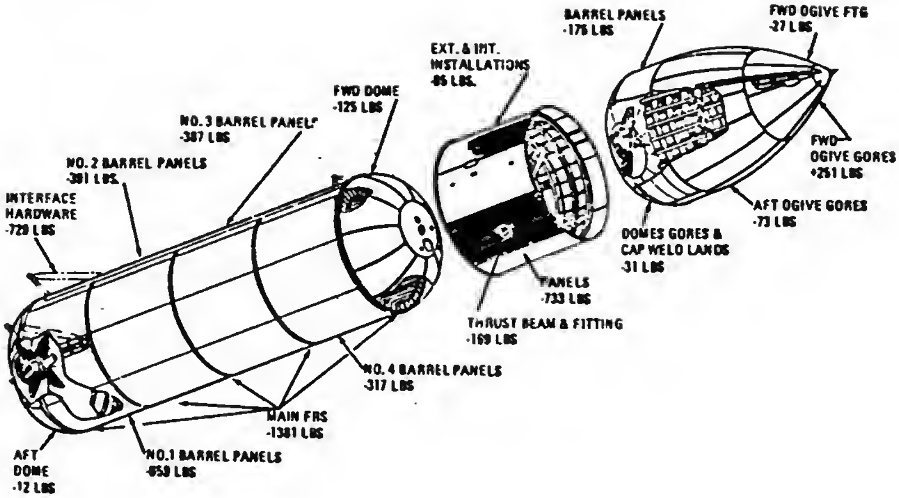
BOOSTER MODIFICATIONS

NASA plans to make a change to the Shuttle's Solid Rocket Boosters that will reduce their weight substantially and provide an increase in the Shuttle's payload carrying capacity by about 2,720 kg (6,000 lb).

Pending approval for reprogramming of funds, NASA plans to replace eight of the 11 metal segments of the current booster motor case with four segments made from composite filament material. Other motor components, including the metal forward and aft domes and the External Tank attach segment of the metal case, would remain unchanged.

A request for proposals has been issued for design and development of the filament wound case.

The new filament wound case is needed for high performance launches primarily into near-polar orbit from Vandenberg Air Force Base in California. The lightweight motor case will help to compensate for reduced lift capabilities when launches from the West Coast cannot take advantage of the added velocity provided by the Earth's rotation. The filament wound case can



Weight-saving measures underway on the Shuttle External Tank should reduce the empty weight by 6400 lb (2900 kg). More than 5000 lb (2300 kg) of that will come from improvements in the structure itself.
NASA

also be used to boost extra heavy payloads into Earth orbit from the Kennedy Space Center in Florida.

The lightweight case for the boosters was one of several options studied by NASA to increase the Shuttle's payload capacity. First use of the motor would be in late 1985.

Should the plans be approved, a series of test firings using filament wound case configured solid rocket motors will be conducted by the Thiokol Corporation in Utah, under the direction of NASA's Marshall Space Flight Center.

SHUTTLE INSULATION

Engineers in the Spray-On Foam Insulation (SOFI) facility at NASA's Marshall Space Flight Center in Huntsville are presently looking for ways to reduce the cost of the thermal protection system for the Space Shuttle's External Tank.

'There are a lot of improvements that can be made to the insulation used in the tank's thermal protection system," said Paul Shuerer, chief of the Process Engineering Division in the Materials and Processes Laboratory. This laboratory is responsible for operation of the facility and the testing and evaluation of materials used on the External Tank.

"In the facility we are able to control the many factors that affect the foam's application and performance. SOFI requires strict control of a variety of factors, including the humidity and the temperature of the facility as well as the temperature of the foam and the structure to which it is being applied."

Application is accomplished by a robot computer-synchronized with a precision turntable. "This automated system allows us to control the test operations and to precisely simulate the actual conditions that will exist in the production spray cells at Michoud [Michoud Assembly Facility in New Orleans], including the speed with which the foam is applied and the amount of overlap time between passes. These are critical factors affecting the quality and performance of the applied foam," said Shuerer.

"We are testing a foam that could replace the combination of thermal protection materials used on the aft dome of the External Tank." This dome presently uses a composite thermal protection system, consisting of a Super-Light Ablator (SLA) and Spray-On Foam Insulation. It must withstand the radiant heat from the Shuttle engines and Solid Rocket Motors, and protect the aluminium in the aft dome.

"The foam we are working on is a higher performance material than the present foam, and we and Martin Marietta Corporation [the tank manufacturers] believe it will allow us to eliminate the SLA from the aft dome."

The elimination of the SLA from the aft dome will reduce the cost substantially. SLA costs approximately $50/lb, while the spray foam costs approximately $3/lb. Additionally, the foam weighs substantially less, and will allow additional payload weight (since the External Tank is carried almost all the way into orbit).

"This is only the beginning of the work we are now able to accomplish in reducing the cost of the External Tank," said Shuerer. "A variety of other ideas is being discussed and studied, including eliminating the SLA in other areas, precision molding of insulation applied to components, lower cost welding techniques and high speed machining."

GODDARD CENTER DIRECTOR

Dr. Noel W. Hinners, Director of the National Air and Space Museum, has been appointed Director of NASA's Goddard Space Flight Center, effective 14 June.

Hinners became Director of the National Air and Space Museum in April 1979. Prior to that he was Associate Administrator for Space Science at NASA Headquarters from June 1974 to April 1979 and he served as Director of Lunar Programs in the Office of Space Science. He joined NASA in 1972 as Deputy Director and Chief Scientist, Apollo Lunar Exploration.

Hinners served as chairman of NASA's Lunar Dust Erosion Study Committee in 1969-70, and the Apollo Photo Data Users Group in 1971. He was also chairman of the Apollo Site Committees for the Apollo 12-17 missions. He currently chairs NASA'S Solar System Exploration Committee.

SOVIET CETI CONFERENCE

In mid-1981 the Soviet Academy of Sciences hosted an international convention on Communication with Extraterrestial Intelligence (CETI). The conference was attended by some 200 scientists from the Soviet Union, the United States and some European countries, writes Cerald L. Borrowman.

While many scientists believe it likely that life exists elsewhere in the universe, the question confronting them is how to locate it or communicate with it. Radio may be the best means since any other civilization that is scientifically oriented

would utilize radio waves for long distance communication. Radio transmitters are also cheaper and easier to construct than spacecraft. Therefore, astronomers can use their radio telescopes to examine individual stars to determine if they are broadcasting radio signals.

The 1981 CETI conference was given wide coverage by the Soviet media and four cosmonauts were in attendance. Among them was Vitaly Sevastyanov who is often on Soviet television describing the efforts of the Soviet Union in the exploration of space.

The sharp contrast in interest in CETI between East and West is highlighted by the support provided by governments. In the West there is a great deal of difficulty in obtaining funds to perform CETI research.

According to Barney Oliver, an American CETI researcher, "The Soviet Union tends to have an interest in science and advanced science rather than in engineering and technology. It seems to breed scientists rather than engineers." A CETI concept has been sold at a higher level in the Soviet Union than it has in our (the US) government. And I think that if they see us dropping it they will probably race ahead much faster than they have been. And if we drop it, I hope they do. It serves us right."

The Soviets attending the CETI conference revealed that the Soviet Union is planning some very large and very sophisticated equipment to perform specific CETI observations.

STELLAR EJECTION

What is believed to be the first direct evidence of a violent ejection, or jet, from a star relatively close to the Sun has been detected by astronomers.

Most of the jets observed by astronomers indicate violent ejection of matter from the centre of active galaxies or quasars. This most recent observation, however, reveals an extraordinary jet structure in a binary star system near the Sun, known as R Aquarii. In contrast to the only other star known to have jet structure in our galaxy, SS 433, R Aquarii is much closer to the Sun, a distance of only 750 light years.

Dr. Andrew Michalitsianos of the Goddard Space Flight Center describes the jet, seen with the Very Large Array radio telescope located at Socorro in New Mexico, as "an extended, well collimated (directional) jet which is coincident with a similar structure seen in visible light by Dr. George Herbig with the 305 cm (120 in) telescope at Lick Observatory. This jet has a length of about 20 times the size of our Solar System."

Dr. Minas Kafatos, also at Goddard, estimates that the material in the jet could be moving at 2,000 km (1,080 mi) per second.

"We believe that the presence of a jet in R Aquarii is evidence for an accretion disk of material captured by an unseen star companion of the cool red variable R Aquarii," said Kafatos. The accretion disk, estimated to have a diameter 25 times the Earth's distance from the Sun, would be just observable with the Space Telescope (due to be launched on the Space Shuttle in 1985) because of the proximity of this system to the Sun. Therefore, R Aquarii may be the only object in which astronomers can directly examine the formation of jet structure.

As Star SS 433 is 20 times farther from the Sun than R Aquarii, it would not provide a favourable opportunity for observation, astronomers said.

In a related development, radio observations of the jet structure by Robert Sopka of the University of Maryland, they said, showed a previously unknown radio source. If proven to be associated with R Aquarii, it may be material previously ejected during an outburst seen in the early 1930's.

New observations are planned by the Goddard astronomers using NASA's orbiting International Ultraviolet Explorer.

TIROS N SERIES EXTENDED

The Tiros N/NOAA series of environmental satellites will be extended beyond the originally planned NOAA A-C by the addition of NOAA H-J satellites. The new satellites should allow the system to continue operating beyond 1990.

The satellites work in pairs in Sun-synchronous (near-polar) orbits relaying a variety of environmental data: high resolution day and night cloud cover images, measurements of sea surface temperatures, profiles of water vapour in the troposphere and lower stratosphere, and temperature profiles of the middle and upper stratosphere. Data from automatic platforms in remote locations on the Earth are also relayed to collection points.

NASA launched the prototype (Tiros N) of the system on 13 October 1978. NOAA (National Oceanic and Atmospheric Administration) were then responsible for the operation of its successors: NOAA-A (NOAA 6 in orbit) on 27 June 1979 and NOAA-C (NOAA 7 in orbit) on 23 June 1981. NOAA-B failed to reach orbit on 29 May 1980.

Apart from the addition of the H-J satellites, three more payloads are planned for those awaiting launch. Search and Rescue demonstration hardware for use during emergencies will fly aboard NOAA E-J. The Soviet Union will orbit similar equipment. The Earth Radiation Budget Experiment will measure radiation arriving at, and leaving the Earth to aid in producing models of the atmosphere. It will be carried by NOAA-F and G; H-J will carry dummies to maintain balance. The Solar Backscatter Ultraviolet Radiometer is adapted from a Nimbus experiment to monitor the global distribution of ozone on a long term basis. Present plans call for it to fly aboard NOAA G-J.

The E-J satellites will now be known as Advanced Tiros N (ATN), similar to their predecessors except that the Equipment Support Module will be stretched by 48 cm to accommodate the new hardware.

IN THE PAST

25 Years Ago . . .
September 1957. North American Aviation began construction of the first X-15 rocket-powered aircraft. The three craft eventually flew 199 times.
4 October 1957. The USSR opened the Space Age with the launching of Sputnik 1.

20 Years Ago . . .
4 September 1962. Nine aerospace companies made their proposals to NASA for the Apollo Lunar Excursion Module. Grumman Aerospace was eventually selected.

15 Years Ago . . .
24 August 1967. The Apollo 4/Saturn 5 vehicle was moved to Launch Complex 39A. On 9 November 1967 it became the first Saturn 5 to fly.
10 October 1967. The Apollo 6 spacecraft completed tests at its factory in Downey, California before shipment to the Cape for the second Saturn 5 launch.

10 Years Ago . . .
28 August 1972. The Apollo 17 launcher and spacecraft was rolled out to the pad for a December lift-off.

5 Years Ago . . .
4 September 1977. NASA announced that the network of Apollo instruments on the Moon would be shut down at the end of the month.
29 September 1977. The Soviet Salyut 6 space station was launched. Five years later it was still operating.

D. J. SHAYLER

THE ARIANE LAUNCHER

By Bruno Gire

Introduction

Following the successful launch of Ariane L04 last December, the new European launcher has now been declared to be operational. For the first time, Europe has direct access to space. NASA now has to face an independent challenger for customers, thus introducing a new factor into the design and marketing of launch vehicles.

Ariane was designed as a low cost, high capacity rocket using proven technology and was aimed at the lucrative communications satellite market. This philosophy has affected the design; for example, performance had to be traded against low production costs.

This article presents a technical description of Ariane, showing its construction in a series of cutaway diagrams, and looking at future versions. Background information can be found in Andrew Wilson's article "Ariane Into Space" in the October 1981 issue of *Spaceflight*, pp. 259-265.

Structure

Details of the whole vehicle are given in diagram A (centre pages). Items were standardized where possible. Alloys used include steel for the first stage tanks and propulsion bay frames, as well as aluminium alloys for the second and third stages and the fairing. Titanium was used for the pressurization vessels at the upper stages.

Viking Engines

The Viking motors of the first and second stages are developments of motors used 20 years ago for the French Véronique and Vesta sounding rockets, and later the Diamant (first stage) and Europa (second stage) satellite launchers.

Their evolution includes:

- 1966: first studies on 40 tonnes thrust, turbopump-driven engines (based on Diamant B first stage engine).
- 1968: studies for stage to replace Blue Streak in the Europa II. Four Viking engines.
- 1970: Europa III studies; cluster of four of five Vikings considered with up to 60 tonnes thrust each (for Viking II).
- 1972: CNES, the French space agency, propose the L-3S launcher after the cancellation of Europa III. Called for four Viking II in first stage and one in second. L-3S became Ariane.
- 1974: Viking II improved by extending nozzle; renamed Viking IV.

Ariane uses four Viking V (thrust 66 tonnes at altitude) and one Viking IV (thrust 71 tonnes at altitude) in the first and second stages, respectively. The nitrogen tetroxide (N_2O_4) and Unsymmetrical Dimethylhydrazine (UDMH) propellants require less sophisticated engine design and handling than liquid hydrogen and oxygen. A portion of the propellants are fed into a gas generator to drive the turbopump. There, the resultant gases are cooled to 600°C by using water vapour

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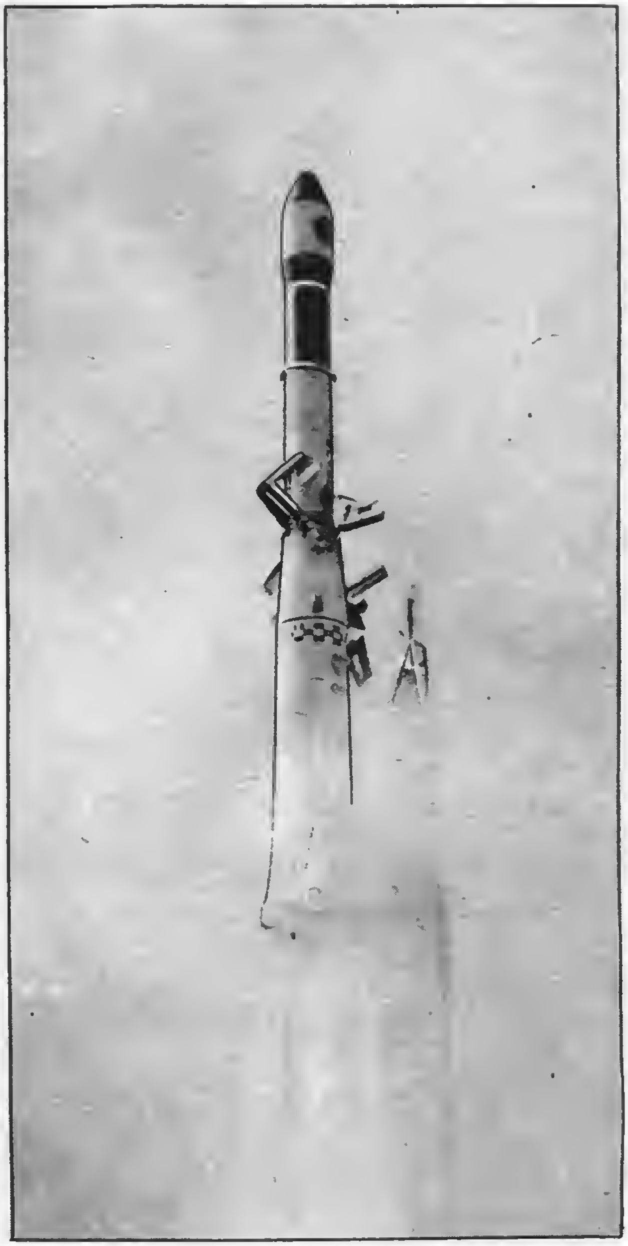


The launch of Ariane L03 in June 1981.

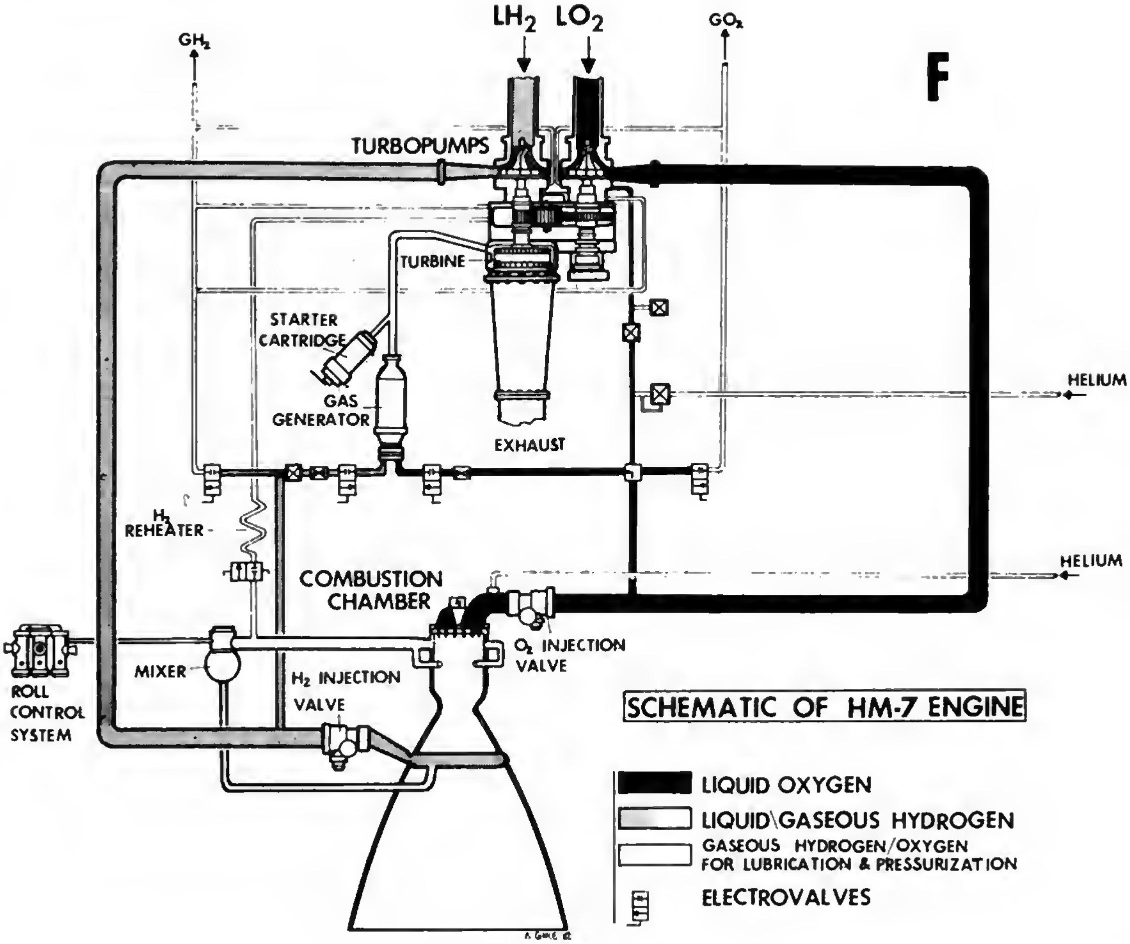
ESA

Table 1. Ariane I stage characteristics

Stage	L145 (first)	L34 (second)	H8 (third)
Height (m) with engine	18.4	11.5	8.35
Diameter (m)	3.8	2.6	2.6
Dry wt. (t)	13.27	3.285	1.157
Fuelled wt. (t)	159.55	36.79	9.60

Table 2. Ariane I engine characteristics

	Drakkar	L34	HM7/H8
Engines	4 × Viking V	1 × Viking IV	1 × HM7-A
Total thrust (vacuum, t)	264	71.3	6.16
SI (vacuum, s)	278	293.5	442.4
Pressure (vacuum, atm)	53	53	30
Burn time (s)	138	131	563
Propellants		UDMH/N_2O_4	LH_2/LO_2
Height (m)	2.87	0.75	1.71



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from, in the first stage, a 3000 litre toroidal tank. The gases can also be used, when further cooled, to pressurize the tanks and provide power for gimballing the nozzles. The Viking IV and V designs are identical except for the gimbal and nozzle systems.

Third Stage Engine

The HM7 is the first operational cryogenic engine in Europe, using liquid hydrogen and oxygen. Its development by SEP (Société Européene de Propulsion) included:

- 1962: studies for 4 tonnes thrust four-chamber HM4 for Diament A second stage.
- 1967: first tests.
- 1968: cancellation following successful tests.
- 1969: cancellation of studies for 6 tonnes thrust version of HM4.
- 1969: Europa IIIN second stage: called for 7 tonnes thrust single-chamber HM7 using HM4 turbopump.
- 1970: Europa IIIB second stage: design developed from HM7 with increased chamber pressure.
- 1972: cancellation of Europa.
- 1972: studies for L-3S third stage. Based on HM7, resulted in Ariane H8 third stage.

The H8 propulsion bay is shown in diagram D; HM7 operation can be seen in diagram F. The latter diagram shows that gases from the gas generator are used to turn the turbine and then expelled overboard. The Shuttle main engine re-uses the gases to add thrust but this leads to a more complex design.

Payload Fairing

The fairing is shown in diagrams A and G. Dual satellite capability is available using the Sylda (Système de Lancement Double Ariane) adapter, a 108 kg two part carbon fibre structure. Diagram G shows the separation sequence.

Future Ariane Versions

It was clear from the beginning that the Ariane I version was not powerful enough to compete with American launchers (1780 kg into geostationery transfer orbit.) Ariane II and III were approved in 1978 and in January this year ESA gave approval for the IV version. A possible Ariane V will be considered later.

Ariane II

The first II launch will be the 12th vehicle. The first stage

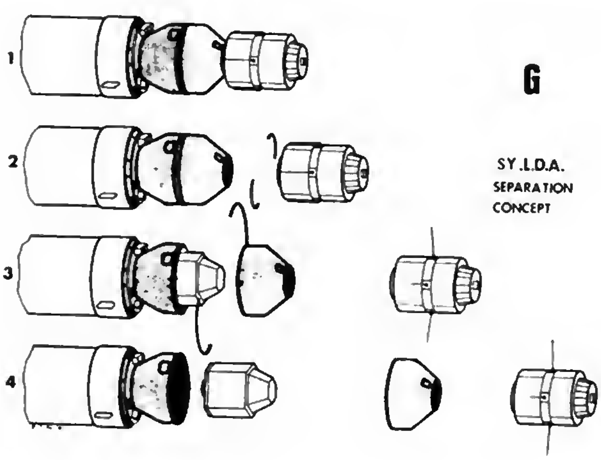


Table 3. Ariane family performance

Vehicle:	I	II	III	42P	44P	42L	44LP	44L
Launch wt (t)	207	214	233	317	335	380	397	460
Total launch thrust (t)	249	264	404	404	544	396	536	528
Payload into transfer orbit (kg)	1780	2100	2560	2700	3100	3300	3800	4300

Note: for the Ariane IV family the second digit indicates the number of boosters carried; the letter indicates whether liquid or solid. The 44LP carries 2 solid and 2 liquid.

has 9 per cent more thrust, achieved by raising chamber pressure to 58.5 atmospheres. Thrust per engine: 66 tonnes (sea level); 76 tonnes (vacuum). It is hoped to recover the first stage (tests will be carried out during the seventh I launch) in order to reuse some of the components. If successful, total launch cost could be reduced by 10 per cent.

The second stage Viking IV will be increased in thrust from 71.3 to 76 tonnes (vacuum).

The HM7 third stage engine will use a lengthened nozzle and increased chamber pressure to raise its specific impulse from 442.4 to 444.2 s. The third stage will be lengthened by 1.3 m to carry 10.5 tonnes more propellants.

Ariane III

Ariane III is identical to its predecessor except that it will include boosters (see diagram B) and a modified fairing to allow larger payloads. Its first launch is schedule to be L13 in December next year although the lengthy delays caused by the L5/Marecs satellite modifications may push it further back.

Ariane IV

Ariane IV will form a whole family by itself by using a variety of liquid and solid strap-on boosters and different payload shrouds. First launch is planned for L26 in October 1985.

Modifications include:

Stage 1: tanks lengthened from 10.63 to 16.83 m, propellants from 148 to 210 tonnes. Reinforced structure.

Stages 2 & 3: identical to earlier versions but with reinforced structure.

Fairings: four types available, heights of 10.5, 9.6, 11.8 and 13.1 m, all 4 m diameter. The two largest will use the Spelda adapter (Structure Portense pour Lancement Double Ariane). See fairing diagram.

The solid boosters will be the same as those for Ariane III but with more propellant. The liquid booster has still to be developed but will use single fixed Viking V engines (see diagram A.) The boosters' characteristics are (with values for the solids in brackets):

length:	16	(8.3) m
diameter:	2.3	(1.07) m
Mass:	40	(8.7) t
Prop. Mass:	37.5	(7.37) t
Thrust:	66	(78.5) s
Propells:	UDMH/N_2O_4	(Flexadyne)

Ariane V

The form of Ariane V – if it is built at all – is by no means certain. During 1980/81 CNES produced a variety of designs based on uprating the Ariane IV, including new third and fourth stages and a 4 m diameter second stage (which was later reduced to the same diameter as Stage 1). The third stage would be developed from MBB's H10 Ariane IV third stage and housed inside a 4.2 m diameter fairing. The fourth stage (apogee) motor would be a modular design based on the cancelled Space Tug. This 1981 project included four basic versions (with/without third or fourth stages) and was used as the basis for the preliminary design of the CNES Hermes manned shuttle study.

More recently, studies have included the Ariane IV first and third stages but with a cryogenic second stage built around a new HM60 (Vega) 60/80 tonnes thrust engine. It would be comparable in performance to the J-2 engines of the Apollo-Saturn 5. Provisional characteristics are:

Thrust:	900 kN (vacuum)
SI:	444s
Burn time:	291s (restartable)
Pressure:	100 atm
Wt:	1450 kg

Ariane V will be required around 1995 for the large payloads expected by then. There would be three main versions.

Ariane VB: for low Earth orbits.
Ariane VC: for geostationary payloads; with H9 cryogenic third stage, 9 tonnes thrust.
Ariane VH: a two stage version for use with Hermes manned shuttle.

Payload volume would be half that of the Space Shuttle, and similarly for the payload mass. Other possibilities include reusable first stages. A decision on the Ariane V version will be required before 1986 if it is to be available by the mid-1990's.

Acknowledgements

Many thanks to Mrs. Comérieux (Press Department, ESA), Mrs. Compard (Press Department, Aérospatiale), Mr. Metzlé (Press Department, CNES) and Mr. Schibler for their help.

NEWS FROM THE CAPE

By Gordon L. Harris

VIEW FROM THE TOP

The Kennedy Space Center's third director, Richard G. Smith, has spent 31 years in rocket and space developments, beginning his career with the Army-von Braun team at Redstone Arsenal in Alabama. At 53 he is a forthright engineer-trained manager who talks frankly about sensitive issues related to his business.

For example, he would like to see private industry take over one of NASA's expendable vehicles: Delta, managed by the Goddard Space Flight Center or Centaur, managed by the Lewis Research Center. His team has launched these rockets from Complexes 17 and 36 on the Cape since the early years of American space activities. In a recent discussion with *Spaceflight*, Smith predicted both vehicles will be in service well into 1987. They were supposed to have disappeared in 1980 when Shuttles became operational, a stage in development now anticipated for this November.

Recognising a "growing interest" in privately-financed boosters for commercial users, Smith found no absolute prohibition to their use of a Cape launch complex. He said that David Hannah, president of Space Services in Houston has talked with General Dynamics, manufacturer of Centaur and its Atlas booster. Hannah's firm tried to develop Percheron, a low cost liquid fuelled booster that failed its initial test at Matagordas Island on the Gulf coast. The firm then turned to a solid propellant rocket.

Hannah has employed several retired NASA personnel as consultants or associates: Lee Scherer, Smith's predecessor at KSC; Max Faget, engineering chief at the Johnson Space Center and Donald "Deke" Slayton, former astronaut.

Smith is the first NASA official to mention the possibility of a private firm operating on the Cape and the first to suggest such an enterprise might take over an existing vehicle. Hannah hopes to provide boosters at rates competitive with NASA's $26 million for Delta and $40 million for Centaur.

There is economic reason for Smith's suggestion. NASA maintains both Cape complexes and their contractor teams while recovering only the actual cost of vehicles and services directly related to each launch. Eliminating either Delta or Centaur would free NASA funds for other purposes.

As to future heavy lift vehicles, Smith believes they should follow the development of a permanent, manned station carried into orbit sectionally by Shuttles. He referred to a Marshall Space Flight Center study that makes use of large solid boosters for augmenting Shuttle thrust. Once jokingly referred to as "big, dumb boosters," such vehicles would be utilised for very heavy payloads. If the agency embarks upon that kind of project, Smith would build a new launch pad north of Complex 39 in Mosquito Lagoon which is under Federal jurisdiction.

Spaceflight asked Smith to assess KSC activities five and ten years hence. These are his forecasts:

- 24 Shuttle flights per year by 1987, 30 by 1992,
- Government-contractor work force stabilised at 10,000,
- Further conversions of VAB bays to accommodate stacking Orbiters, tanks and solid boosters on mobile launchers,
- Bringing Pad B, Complex 39 on line by 1985. He noted the risk until then in operating Shuttles off Pad A only,
- Reducing turnaround time between flights to 60 days and eventually to 45 days (requires improvements in ground and flight systems).

By early 1983, he said, KSC will be able to move faster than the Johnson centre between flights. His assessments were based upon a four-Orbiter fleet. *Challenger*, the second, is due for first launch in January 1983. *Discovery* arrives later that year and *Atlantis* in 1984. One of the four, perhaps *Columbia*, will be turned over to the military for West Coast polar orbit missions beginning in late 1985. KSC's launch team will prepare the first two or three Orbiters and ferry them to Vandenberg Air Force Base when ready for launch. Until then, Shuttles flown here will carry military as well as civilian payloads (the first flew in STS-4).

Richard Smith, Director of the Kennedy Space Center.

NASA

"The real issue is Defense long range requirements," Smith added. "It may turn out that they need a dedicated Shuttle fleet reserved for military missions. If so, it would be easier for NASA to set up a quasi-commercial type operation here for domestic and foreign customers."

Last May NASA considered its Shuttle management plan to decide whether to contract for launch processing or delay "because it may be too early to release the system to industry." Meanwhile, eight support contracts will be combined into one in October 1982. The winner will employ over 2,000 personnel for such functions as police, fire, medical, supply, utilities, technical library, printing, mail distribution and other housekeeping duties.

Will the Mission Control Centre return to the Cape (which lost it to Texas midway through Gemini)? Unlike some NASA associates, Smith doesn't think it will. He asked if the facility will be needed when Shuttle flights become routine. Nor is it sensible to move a costly facility and a large group of skilled people. "We don't have that expertise here," he observed. On the other hand, Smith indicated MCC might remain in place but operate under different management.

Some of the increase in Shuttle launch rates will establish that permanent orbiting station for which KSC will contribute

in development. Techniques worked out here for servicing vehicles and spacecraft are applicable in orbit as well. Calling a station "the logical next step," Smith strongly backed its value for space processing.

NASA SPACE STATION

NASA's campaign to obtain support for a manned space station took a new turn when Administrator James Beggs disclosed that he approached Japan and the European Space Agency about a joint venture.

The agency abandoned its 80 ton Skylab space station, launched by a two-stage Saturn V in 1973, and visited by three astronaut crews that year and the next riding Apollo capsules launched by Saturn 1Bs. NASA gave up a second Skylab, although hardware was available, when forced to apply more funds to the delayed Shuttle project.

Beggs instructed Skylab's parent, the Marshall Space Flight Center, to study a "bare bones" space platform supplied by Shuttles while Johnson Space Centre studies an elaborate and more costly station.

Assuming the Reagan Administration supports an international undertaking, NASA has not received unqualified backing of Congress. *Spaceflight* asked Chairman Don Fuqua, of the House Committee on Science and Technology, how his group views the Beggs concept. Fuqua replied: "The Committee has urged establishment of longer range goals for the civil space programme and the space station would appear to be a logical step. The Committee continues to encourage international cooperation in our space activities. While I would not want to endorse international participation without examining specific agreements, I do believe that international participation in such a project warrants consideration."

Fuqua's committee is influential in shaping American space projects because it authorises NASA budgets. The committee has called for a long range programme (see *Spaceflight*, Vol. 24, No. 3). Among findings of a 1981 committee report was this: "Successive US administrations have failed to establish long term goals for the civilian space programme. A high challenge space engineering initiative is technically feasible and desirable. A prime candidate would be establishment of a manned, multi-purpose, open-ended space operating base in low Earth orbit." The report did not advocate an international base.

Fuqua also cited the need to balance science, applications and transportation activities within NASA. The agency was asked to reaffirm a commitment for continued exploration of the Solar System and to develop plans for a global resource information system to aid developed and developing countries.

NASA is organising a "task force" to plan for the space station. As partial justification for the enterprise, Terry Finn, agency deputy director of industry affairs, said "we can't afford not to build it." Otherwise, large scale layoffs will occur in the aerospace industry which has been heavily involved in Shuttle work.

The first instalment of funds will be requested in FY 1984, a new budget due on 1 October. Philip Culbertson, No. 3 in the NASA heirarchy, will head the study group. The basic concept is to fly portions of the station via Shuttles and assemble them in orbit. It would accommodate three to five people. Meanwhile, study efforts under way at Marshall Space Flight Centre and Johnson Space Centre will be accelerated.

NASA has recently announced that a Space Station Task Group will study the possibilities for establishing a permanent space station in low Earth orbit by the early 1990's. Deputy director of the study is Bob Freitag, a Fellow of the Society for many years. Bob is pictured here on the occasion of the presentation of a BIS bronze medal to him at the US Embassy in London in July 1979. On the right is space correspondent Reg Turnill; both will be speakers at our Space '82 "space weekend" in Brighton during November.

FIFTH ORBITER?

Prudential Insurance has committed funds in support of private financing of a fifth Shuttle Orbiter. The giant firm has acquired an interest in Space Transportation Co. which proposes to give a thousand million dollar vehicle to the Government in return for marketing rights on all Shuttle cargoes. Rockwell International, prime Shuttle contractor, has said a start must be made on an additional Orbiter in 1983, otherwise the company will release engineers and technicians who are building *Discovery* and *Atlantis* as sister ships to *Columbia* and *Challenger*. NASA estimates that 30 per cent of Shuttle payload space will be available for commercial cargo. *Columbia* will carry two commercial communications satellites during the STS-5 mission in November. While Gannett News Service said that NASA will collect a fee of $18 million for each satellite, one of the users, Satellite Business Systems, said it will pay only $6 million.

SHUTTLE RESTRICTIONS

Newsmen covering US space activities, accustomed to NASA's open-handed policy over the last 24 years, encountered a sharply contrasting policy on 20 May, shortly before the fourth Shuttle launch. This time Brig. Gen. Richard F. Abel, public affairs director of the US Air Force, quietly spelled out military plans for STS-4 which carried a military payload.

Media were to be informed, Abel said, that a defence cargo was aboard and no more. The same rule will apply to later Shuttle flights. Further, video transmissions from *Columbia* (or other Orbiters) will not reveal the shape, size of location of a military satellite in a payload bay. NASA's detailed flight plans, released to newsmen in advance, will not disclose any crew activity associated with military cargo or the time and location of its release from a Shuttle.

Abel patiently explained that policy regarding release of information will follow Air Force practice concerning satellites launched by expendable vehicles like Titan. No advance notice will be given about a launch and when it does occur a military spokesman will simply confirm the fact without revealing any data regarding mission or cargo.

Abel's explanation was made at the Johnson Space Center where newsmen heard NASA briefings about the STS-4 mission, last of the development flights, and scientific and commercial experiments aboard *Columbia*.

Abel's statement that "we will not disclose information useful to potential adversaries who have collection devices" touched off an argument with reporters who contended that Congressional testimony and technical publications available to the press told much of military space hardware. "When mated to the shuttle," Abel replied, "it becomes classified." He asked the media to "work with us" in the interest of national defence, citing a growing reliance upon space systems for communications, surveillance and weather information available to US forces world wide.

For the first time, correspondents heard "No comment" from NASA flight director Charles Lewis when asked direct questions about the Defense mission. Did the military review the security clearances of NASA and contractor personnel involved in STS-4? "No comment." Abel added that was a NASA matter because the agency operates the Shuttle while the Air Force is a user. Reporters contended that "they (USSR) know and we know they do", so why not tell us? Abel reiterated his statement that "we're not going to reveal information useful to potential adversaries."

He was asked what additional precautions were taken at Kennedy and Johnson Space Centers to maintain security. Abel explained that Defense will handle military cargo at KSC while the third floor of the Mission Control Center has been modified to ensure the security of documents and communications. Other precautions were introduced at the Goddard Space Flight Center in Maryland, in charge of NASA's tracking and communications networks. Cost figures were not immediately available. Were astronauts Mattingly and Hartsfield to have anything to do with the Defense satellite? "There will be some crew involvement in all Defense missions involving Shuttles," Abel answered.

Dubbed "Defense 82-1" by the press, the first military spacecraft carried by *Columbia* was installed while the vehicle was on the launch pad, further reducing the numbers of personnel who saw and handled it.

Since the Department of Defense will be the largest single provider of Shuttle cargoes, it appears that the press corps will continue to chafe at security restrictions applied to an otherwise open programme.

MILITARY SHUTTLE

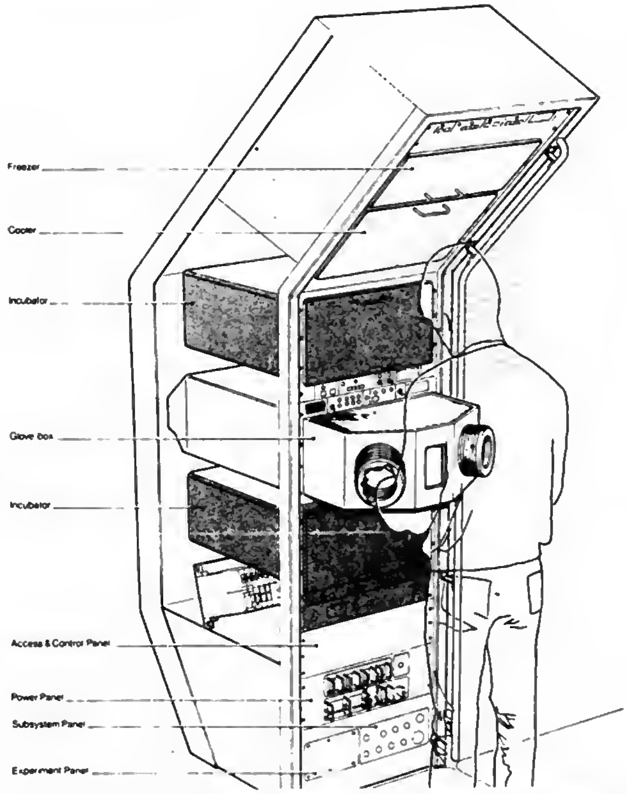
Senator William Proxmire insists that the Air Force should pay more for Space Shuttles. He cited a report indicating 114 of 234 missions through to 1994 will be military-related. By 1987, he added, military payloads will represent 48 per cent of flights that year. Senator Harrison Schmitt obtained committee approval later to add $400 million to Defense budgets of FY 1983 for Shuttle and related space activities. An equal amount, he said, should become available to NASA for planetary and scientific missions.

MATERIALS PROCESSING

Warning that a conservative approach to exploiting space technology for economic purposes may cost the U.S. dearly, Comptroller General Elmer Staats has urged Congress to provide more funds for materials processing research. Staats heads the General Accounting Office established by Congress to audit Federal programmes and agencies.

The GAO report appeared in January 1980 when NASA budgets under President Carter maintained a $10 million level for materials processing over a three-year span. President Reagan's 1983 budget increased the amount to $26 million which is still insufficient according to 100 scientists, programme managers, economists, industrialists and government officials with whom GAO surveyed the situation. Their concern is that other nations may seize opportunities to surpass American capabilities in this field.

Processing experiments were included in early Shuttle test missions but NASA's projections fall far short of GAO proposals. The report's perception of foreign competition continues to be valid and is especially interesting because it comes



West Germany, as pointed out in the text below, have expended considerable effort in developing Spacelab and its uses. Shown above is "Biorack", to be used for cell and molecular biology investigations during the German Spacelab D-1 mission.

ESA

from a Federal office removed from space activities at a time when Congress and the President are locked in a dispute over huge budget deficits.

GAO commented, "Researchers in industry, academia and Government, optimistic about U.S. prospects in materials research are deeply concerned about the growing emphasis and commitment by other countries. Their concern is not that others are ahead of us now. Rather, once the Shuttle and Spacelab are operational (1983) and used by international competitors, their heavy emphasis could lead to technological and economic advantages which may be difficult to overcome."

A condensed description of GAO findings mentions:

1. Success of the joint Swedish-West German TEXUS sounding rocket programme when the U.S. has terminated a similar effort. TEXUS has been used in low gravity materials research in preparation for more sophisticated research on Spacelab.

2. West Germany took the lead in developing Spacelab. It also undertook a comprehensive set of generic research, something the U.S. has not attempted. The German work is complemented by expanding national programmes among European Space Agency members, particularly in low gravity materials science.

3. The USSR has accomplished impressive materials research in Salyut 6 which is available to bloc countries. Before the Polish confrontation, that nation conducted a number of materials science experiments in Salyut. Recent intelligence suggests the Soviets have 350 top materials scientists engaged in space related research.

4. Japan is spending approximately $1000 million a year over a 15 year span if all projects are fully funded. While little is known about the specifics of this effort, glasses, optics and semiconductors are assumed to be among the items of Japanese materials science studies.

5. France is active in the field and flew manned experiments in Salyut. With the success of Ariane, French scientists need not look far for a carrier vehicle. France also plans the unmanned and fully automated Minos, a space laboratory.

6. Other ESA nations are actively engaged in ground-based materials research, preparing for Spacelab experiments. Except for West Germany, however, GAO concluded that other Western European countries suffer from lack of funds.

While GAO found a grateful attitude in Europe towards U.S. cooperation in space missions, the using countries find NASA costs approaching a prohibitive level.

"Recognizing their dependence upon U.S. vehicles, Europeans feel they will be given opportunities only at U.S. discretion," the report observed, "Many resent this dependency and 'minor partner' role."

ESA would prefer to have U.S. lead an international and coordinated space effort. Here GAO turned cautious; "While maintaining and reinforcing international relations, we must also remember that we compete with these same countries technologically and economically."

In conclusion, the report stated; "While U.S. appears to be preeminent in space, there can be little doubt that its lead has diminished. Whether U.S. is to maintain its world leadership depends largely upon events of the next 15-20 years. Its position will be a manifestation of the commitments made now toward future economic and technological advantages."

Commenting upon GAO proposals Anthony J. Calio, NASA associate administrator, said; "Important issues have been raised by GAO. We agree that these are major issues and significant progress on all three fronts (technological maturity, innovation and foreign relations) must await significant scientific and technological achievements as the program moves into the space transportation system."

Calio's response made these points:

1. Emphasis should be placed upon development and demonstration of sophisticated experimental methods and apparatus.

2. Private sector involvement is a key ingredient. Issues such as patent and data rights, exclusivity, and liability are being examined on a case study basis.

3. NASA is focussing on specific problems of technology which must be generated; institutional constraints serve as disincentives.

4. A fundamental principle of cooperative projects is that each side has full and equal access to results.

5. Europeans believe that Ariane will help to reduce costs in using space commercially.

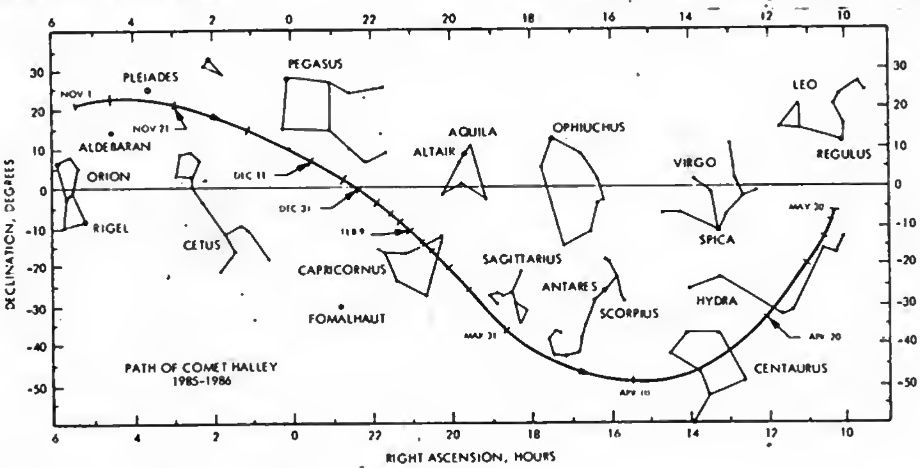
6. When a foreign user pays full reimbursement to NASA the agency will not acquire right to inventions, patents or proprietary data except when the agency determines mission results may have significant impact on public health, safety or welfare.

DO YOUR DUTY!

Chairman Don Fuqua of the House Technology Committee is supporting a bill that would exempt foreign Shuttle payloads from import tariffs. Fuqua pointed out that unless the bill is passed, duty might have to be collected on Canada's $100 million remote manipulator system for *Columbia*. Spacelab and three duplicate RMS devices might be subject to the same taxation.

Society Educational Tours

Halley's Comet – April 1986 – 14 days duration



Owing to the likelihood that Halley's Comet will prove to be a disappointing object when viewed from the Northern Hemisphere, if it can be seen at all, the Society plans to organise a trip to South Africa to view the comet from the Southern Hemisphere. Present indications are that the most favourable time will be the first week in April 1986.

The provisional itinerary is: flight from London to Johannesburg, four nights in Johannesburg, three day tour of Kruger National Park, flight to Port Elizabeth, three day tour of the Garden Route from Port Elizabeth to Cape Town, four nights in Cape Town, and return to London via Johannesburg. There will be plenty of opportunities for viewing the comet.

The approximate cost at present day prices is £1000. This includes all air and coach travel, accommodation in first class hotels, plus breakfast and dinner on coach-travelling days.

We hope to provide each participant with a copy of a Society booklet (provisionally entitled "Halley's Comet Excursion") containing a history of previous Comet apparitions, with space for observations and personal notes about the expedition itself, together with star maps and other details of the 1986 return.

Forms for provisional registration are now available from the Executive Secretary. Please enclose a stamped addressed envelope.

A deposit of £30 per person is required, fully refundable on written cancellation at any time up to December 1985.

Photography expert Douglas Arnold writes:

The pre- and post-perihelion closest approach of the comet to Earth will occur on 27 November 1985 and 11 April 1986 at distances of around 0.62 and 0.42AU, say 57 million and 39 million miles, respectively (somewhat further away than the 3 million miles or so of the AD837 visitation!).

Donald Yeomans of the Jet Propulsion Laboratory predicts that during the period around the 11 April 1986 closest approach Comet Halley will be reasonably bright and high overhead in the southern hemisphere, though invisible from northern Europe. Hence the wisdom of the BIS in planning the trip to southern climes to observe the famous visitor.

Photographically, the Comet will obviously be a teaser. If the predicted visual magnitudes are at all accurate then 400ASA colour and black and white film will be a must. If a comet is very bright you can usually start an exposure programme of from about 1/60 second up to perhaps 2 minutes with a moderate aperture of around f2.8. Star trails occur with the longer times and by two minutes the comet head is beginning to blur. But this is all theoretical anyhow if the gloomy forecasts for Halley are correct. A guided camera will be required, whether piggy-backing on a 'scope or on a drive in its own right. Choice of focal length and optimum aperture for photo lenses will have to wait on the actual event so a good complement of equipment is indicated. Despite the use of 400ASA speed films exposures of anywhere from 2 minutes up to perhaps 20 minutes will be required.

Even if the gloomiest predictions are fulfilled (and my hope is that if the experts can be as wrong with Kohoutek one way, they can be as wrong with Halley 1986 in the other) I've no doubt some splendid images will be secured, particularly "down south". But it will require (in no order of priority) – (a) a fair amount of expenditure; (b) much patience; (c) plenty of film; (d) flexibility in focal lengths available; (e) drive capability for lengthy exposures.

I hope to be there – the best of British luck to us all!

SATELLITE DIGEST - 157

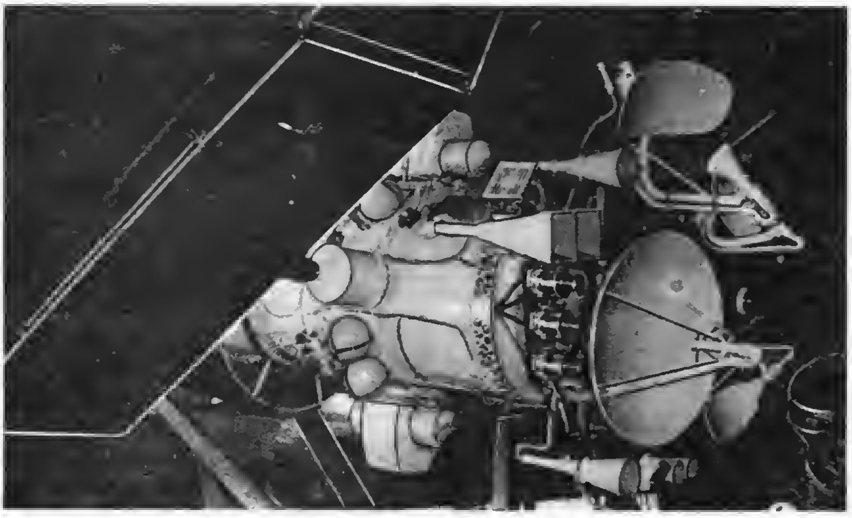
Robert D. Christy
Continued from the July-August issue

A monthly listing of satellite and spacecraft launches, compiled from open sources.

The heading to each launch gives the name of the satellite, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes except where marked with an asterisk, where the time is to the nearest minute as announced by the launching agency

COSMOS 1342 1982-18A, 13084
Launched: 1050, 5 Mar 1982 from Plesetsk by A-2.
Spacecraft data: Possibly based on the Vostok manned spacecraft with spherical re-entry module, instrument unit and a cylindrical, supplementary payload at the forward end. Length about 6 m, diameter (max) 2.4 m and mass around 6000 kg.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: Initially 194×299 km, 89.48 min, 72.88 degrees but manoeuvred during the first day to 227×288 km, 89.70 min, 72.86 degrees and maintained near this height for the rest of the flight with a small manoeuvre on 11 Mar to counteract decay.

IMEWS 13 (OPS8701) 1982-19A, 13086
Launched: 2015, 6 Mar 1982 from Cape Canaveral Air Force Station by Titan 3C.
Spacecraft data: not available.
Mission: US Air Force-launched early warning satellite for missile launches. The previous launch in the series was IMEWS 12 (1981-107A).
Orbit: Initially a geostationary transfer orbit at 29 degrees inclination, then injected into a drift orbit before final stabilisation above 68 degrees west longitude; the same as IMEWS 11 (1981-25A).



GORIZONT displays its array of Earth-sensing instruments (for spacecraft control) and the microwave horns and reflectors of its communications package. The two-panel solar array (one each side of the main body) tracks the Sun as the satellite moves round its orbit. Station keeping is by low thrust rockets in the two packs above and below the body. A cylindrical heat regulator surrounds the rear end of the body which appears to have much in common with that of the METEOR weather satellites.

R. D. Christy

GORIZONT 5 1982-20A, 13092
Launched: 0439, 15 Mar 1982 from Tyuratam by D-1-E+apogee motor.
Spacecraft data: Cylinder with a pair of solar panels, an array of aerial horns and reflectors is located at one end. Length about 5 m and max diameter about 2 m, the mass is around 2000 kg.
Mission: To provide telephone, telegraph and television relay links both within and outside the USSR.
Orbit: Initially a low parking orbit at 51.6 degrees inclination, then an elliptical transfer orbit at 47 degrees prior to injection into geostationary drift orbit with final stabilisation above 54 degrees east longitude (Statsionar 5).

COSMOS 1343 1982-21A, 13096
Launched: 1030, 17 Mar 1982 from Plesetsk by A-2.
Spacecraft data: as Cosmos 1342.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: Initially 197×287 km, 89.37 min, 72.86 degrees, manoeuvred during first day to 227×288 km, 89.69 min, 72.84 degrees. Further raised on 25 Mar to 222×328 km, 90.04 min, 72.84 degrees.

STS 3 1982-22A, 13106
Launched: 1600*, 22 Mar 1982 from pad A of launch complex 39 at the Kennedy Space Center.
Spacecraft data: Re-usable Shuttle *Columbia* - lift off mass 2,031,619 kg including 9658.5 kg of cargo.
Mission: Third flight in the Shuttle system's Orbital Flight Test Programme, crewed by commander Col. Jack R. Lousma of the US Marine Corps and pilot Col Charles G. Fullerton of the US Air Force (both NASA astronauts).

The major objectives of the flight were engineering and included further tests of the remote manipulator system (started on STS 2) as well as measuring the thermal response of the Orbiter's structure during long periods of holding constant attitude with respect to the Sun. The payload bay held a number of experiments as part of a package put together by NASA's Office of Space Science (OSS) and a test article connected with future "Cetaway Special" payloads (officially titled Small Self Contained Payloads). The OSS-1 package was mounted on an engineering model of the Spacelab pallet built by British Aerospace. The instruments consisted of:

Contamination Monitor Package: to measure the build-up of contaminants on the surfaces of the Shuttle during launch and flight. Sources of contaminating materials include outgassing from orbiter and payload structures, thruster firings and waste dumping activities by the crew.

Micro-abrasion Foil Experiment: the first non-US originated experiment to fly on a Shuttle mission, this was developed by the University of Kent, England. The effect of micrometeorite impacts on different thicknesses of aluminium coated on plastic were studied after recovery of the payload.

Plasma Diagnostics Package: a cluster of instruments to study the interaction of the Orbiter with the surrounding space, in particular the magnetic and electric fields present. For part of the time, the package was deployed away from the Orbiter body using the manipulator arm.

Induced Atmosphere Experiment: designed to measure the optical effects of any atmosphere created around the vehicle by volatile materials evaporating from the structure.

Solar Flare X-ray Polarimeter: an astronomical instrument which used metallic Lithium to detect solar X-rays and to measure their polarisation.

Solar UV Spectral Irradiance Monitor: consisted of a pair of UV spectrometers and a calibration source for solar studies.

Thermal Canister Experiment: to help with future, hopefully simpler, designs of thermal protection for space instruments.

Vehicle Charging and Potential Experiment: an experiment to investigate the electrical charging of the Orbiter's structure caused by interaction with the natural plasma of the ionosphere.

Other experiments in the cargo bay but not part of the pallet were:

Getaway Special Verification: a test item containing instrumentation to measure the environment in which future such payloads will fly and operate.

Induced Environment Contamination Monitor: further measurements of the general environment of an orbiting Shuttle, this time actually analysing the induced atmosphere for cross reference with results obtained from the Contamination Monitor package.

Some experiments were also carried in the crew deck area of the vehicle:

Plant Growth Unit: an investigation of plants' production of lignin which has an industrial application as the source of a polymer for bonding wood with other materials. The plants involved were a slash pine (native to the East and Gulf coasts of the US), the mung bean and oats.

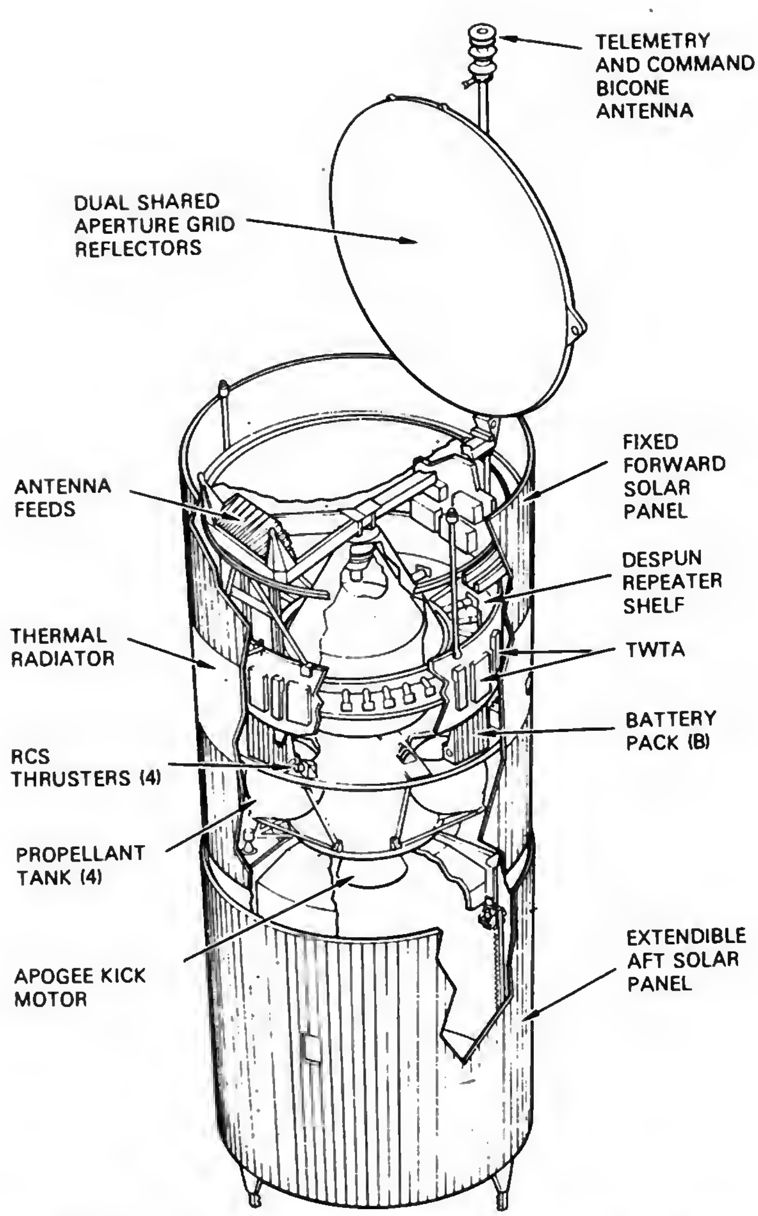
Monodisperse Latex Reactor: a materials processing experiment studying a means of producing monodisperse (identical sized) polystyrene latex beads up to 20 microns diameter for medical and industrial use.

Electrophoresis Test: designed to evaluate the feasibility of separating living cells by their differing surface electric charges.

Heflex Bio-engineering Test: a reflight of an STS 2 experiment which suffered from that mission's premature ending. It studied the growth of dwarf sunflower plants under varying conditions. This experiment was a preliminary test in support of a Spacelab 1 experiment.

Student Involvement Project: the first of a series of experiments evolved by students and submitted through a competition. This particular one, devised by Todd Nelson of Adams, Minnesota, studied the abilities of Velvetbean Caterpillar Moths and Honey Bee drones to fly in zero gravity.

STS 3 landed at White Sands, New Mexico rather than the originally planned site of Edwards Air Force Base, because of heavy rains softening the dry lake bed. Touchdown was at 1605, 30 Mar 1982 with *Columbia* coming to a standstill one minute later. The flight time from lift off to touch down was 8 days and 5 minutes.
Orbit: The highest orbit attained on this flight as a result of manoeuvres using the OMS was 244×255 km, 89.36 min, 38.02 degrees.



The Westar 5 communications satellite was launched by Delta on 8 June towards its position in geostationary orbit. Westar 6 will use Ariane.

Hughes

MOLNIYA-3 (18) 1982-23A, 13107

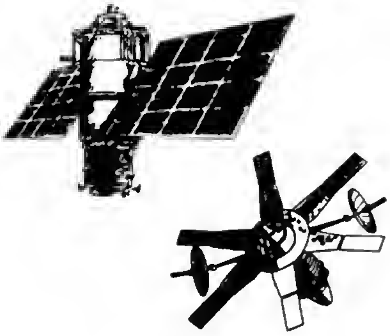
Launched: 0018, 24 Mar 1982 from Plesetsk by A-2-e.
Spacecraft data: Cylindrical body housing instrumentation and the payload is surmounted by a conical motor section. Power is provided by a windmill of six solar panels. Length is about 4m, diameter 1.6m and the mass around 2000 kg.
Mission: Replacement or backup for Molniya-3(15), 1981-30A. The satellite provides long distance telephone and telegraphic communications and transmits Central Television programmes to "Orbita" ground stations in the USSR and other countries.
Orbit: Initially a low parking orbit and then injected into a highly elliptical orbit of 626×40619 km, 735.82 min, 62.87 degrees. Later manoeuvred to 627×39768 km, 718.59 min, 62.84 degrees to ensure daily repetition of ground tracks.

COSMOS 1344 1982-24A, 13110

Launched: 1947, 24 Mar 1982 from Plesetsk by C-1.
Spacecraft data: Cylindrical body with domed ends, enclosed in a cylindrical solar array with length and diameter both around 2m. The mass may be around 700 kg.
Mission: Navigation satellite replacing or backing up Cosmos 1244 (1981-13A).
Orbit: 967×1011 km, 104.95 min, 82.92 deg.

METEOR 2 (8) 1982-25A, 13113

Launched: 0950, 25 Mar 1982 from Plesetsk, possibly by a version of the F vehicle though the Meteor 2 is usually an A-1 launch.
Spacecraft data: Cylindrical body with two, Sun-seeking solar panels. Length about 5 m, diameter about 1.5m and mass around 2200 kg.
Mission: The return of cloud cover and other meteorological data through scanning radiometers and other instruments. The satellite may also have an Earth rescources rôle.
Orbit: 941×961 km, 104.12 min, 82.54 deg. This is slightly higher than previous Meteor 2s which have flown aroun 900 km, 102.5 min.



COSMOS 1345 1982-26A, 13118
Launched: 0902, 31 Mar 1982 from Plesetsk by C-1.
Spacecraft data: not available.
Mission: Military, possibly radar calibration.
Orbit: 504×545 km, 95.15 min, 74.04 deg.

COSMOS 1346 1982-27A, 13120
Launched: 1627, 31 Mar 1982 from Plesetsk by A-1.
Spacecraft data: Possibly based on the Meteor satellites; see Meteor 2(8) above. Mass around 2000 kg.
Mission: Possibly electronic reconnaissance. Like the previous launch, this vehicle's orbit plane is 12.5 degrees to the east of the existing six satellite system. Cosmos 1346 replaces or backs up Cosmos 1222 (1980-93A).
Orbit: 621×660 km, 97.58 min, 81.18 degrees.

COSMOS 1347 1982-28A, 13122
Launched: 1015, 2 Apr 1982 from Tyuratam by A-2.
Spacecraft data: As Cosmos 1342.
Mission: Military photo-reconnaissance, 2 month lifetime.
Orbit: Initially 172×340 km, 89.66 min, 70.36 degrees then manoeuvred several times to counteract decay and provide specific target coverage.

COSMOS 1348 1982-29A, 13124
Launched: 1342, 7 Apr 1982 from Plesetsk by A-2-e.
Spacecraft data: Possibly based on the Molniya satellites.
Mission: Part of the USSR's missile early warning system, replacing or backing up Cosmos 1172 (1980-28A).
Orbit: Initially a low parking orbit then injected into a highly elliptical one of 592×39315 km, 708.71 min, 62.85 degrees. Later manoeuvred to 596×39751 km, 717.61 min, 62.85 degrees.

COSMOS 1349 1982-30A, 13129
Launched: 0015 8 Apr 1982 from Plesetsk by C-1.
Spacecraft data: as Cosmos 1344.
Mission: Navigation satellite replacing or backing up Cosmos 1153 (1980-7A).
Orbit: 968×1012 km, 104.96 min, 82.93 degrees.

INSAT 1A 1982-31A, 13129
Launched: 0648*, 8 Apr 1982 from Launch Complex 17A, Eastern Space and Missile Center, Cape Canaveral Air Force Station, by Delta 3910 with PAM upper stage.
Spacecraft data: A box shaped body, 1.55×1.42×2.18 m, and with a fully fuelled mass of 1152 kg. A single solar panel is counterbalanced by a solar "sail". The satellite was built by Ford Aerospace of the USA for the Indian government.
Mission: The first of two Indian National Satellites (from which the name is derived), it provides 12 transponders for communications (6 GHz uplink and 4 GHz down) and two for direct television broadcasts to small installations (6 GHz up, 2.5 GHz down). These channels can also be used for radio programme distribution and giving disaster warnings.

The dual purpose satellite also carries a very high resolution radiometer for returning whole hemisphere meteorological images (similar to Meteosat), which it does every half hour. The radiometer works in visible and infra-red light.

Some problems were encountered early on with the apogee boost motor firing and satellite deployment. These were eventually overcome.
Orbit: Initially a geostationary transfer orbit at 28 degrees but raised by several firings of the apogee boost motor. Eventually stabilised above 74 degrees east.

COSMOS 1350 1982-32A, 13134
Launched: 1430, 15 Apr 1982 from Plesetsk.
Spacecraft data: as Cosmos 1342.
Mission: Military photo-reconnaissance, recovered or re-entered after 31 days.
Orbit: Initially 171×357 km, 89.80 min, 67.16 degrees but manoeuvred several times during the mission to prevent decay and provide specific target coverage.

SALYUT 7 1982-33A, 13138
Launched: 1945, 19 Apr 1982 from Tyuratam by D-1.
Spacecraft data: Probably similar to Salyut 6, ie a cylinder about 15m long and up to approx 4m diameter with three large solar panels. There is a docking unit at each end designed to take larger spacecraft than Soyuz and Progress, such as the "Star" module tested with Cosmos 929 and Cosmos 1267. The latter was still attached to Salyut 6 at the time of Salyut 7's launch. The mass is around 19 tonnes.
Mission: Manned orbiting space laboratory.
Orbit: Initially 213×261 km, 89.17 min, 51.61 degrees, later manoeuvred to the Salyut 6 operating height of around 340 km, 91.4 min for manned occupation, initally by the Soyuz-T5 crew.

COSMOS 1351 1982-34A, 13142
Launched: 0135, 21 Apr 1982 from Kapustin Yar by C-1.
Spacecraft data: Possibly based on the small "Cosmos" standard body with solar panels, ie an octagonal ellipsoid, mass around 550 kg.
Mission: Not known.
Orbit: 348×547 km, 93.48 min, 50.69 degrees.

COSMOS 1352 1982-35A, 13144
Launched: 0915, 21 Apr 1982 from Tyuratam by A-2.
Spacecraft data: As Cosmos 1342.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: Initially 208×360 km, 90.22 min, 70.37 degrees but manoeuvred after one day to its operating height of 349×415 km, 92.22 min, 70.38 degrees to ensure constant spacing between equivalent ground tracks on successive days.

COSMOS 1353 1982-36A, 13146
Launched: 0940, 23 Apr 1982 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1342.
Mission: Military photo-reconnaissance, recovered after 13 days.
Orbit: 211×241 km, 89.06 min, 82.36 degrees, maintained near this height for the whole mission with a manoeuvre on 30 May to counteract decay.

COSMOS 1354 1982-37A, 13148
Launched: 0255, 28 Apr 1982 from Plesetsk by C-1.
Spacecraft data: Not known but may be similar to the navigation satellites (see Cosmos 1344).
Mission: Military communications using a store/dump technique.
Orbit: 794×807 km, 100.91 min, 74.04 deg.

COSMOS 1355 1982-38A, 13150
Launched: 0955, 29 Apr 1982 from Tyuratam by F-1.
Spacecraft data: Not available but probably several tonnes mass.
Mission: Probably an ocean surveillance satellite carrying out electronic reconnaissance.
Orbit: Initially 428×446 km, 93.33 min, 65.06 deg. and then maintained precisely at that height by a low thrust motor.

SOCIETY NEWS

NEW SOCIETY PRESIDENT

Tony Lawton, a Council member for many years and Vice-President for the past two, has been elected as the Society's new President.

Tony has a special interest in computing the position of the proposed Planet X thought to lie beyond the present limits of the Solar System. He has developed a theory based on resonance (borne out by Voyager photographs of the numerous rings and satellites found in the Saturnian system) from which he is attempting to predict where the new planet might be found. One of the most recent pieces of information is that Galileo recorded the position of Neptune in 1613 (long before it was "officially" discovered in 1781). Its position does not agree with that calculated by projecting its currently-known orbit backwards in time, the conclusion being that there must be a perturbing body.

The new Vice-Presidents are to be Dr. A. R. Martin and C. R. Turner. All three will be actively involved in our Space '82 weekend. Tony Martin will present a talk on "Is Mankind Unique?", while Rex Turner will discuss "The Society – 50 Years Old".

Tony Lawton, the new BIS President.

SOCIETY PUBLICITY

Members may be interested to know how the Society fares publicity-wise, from time to time. Below is a report of some of its current successes. Much is owed to members who put themselves out to assist. Their help is gratefully acknowledged.

Handouts

Many readers availed themselves of the opportunity to distribute at meetings BIS literature obtainable from the Society on a postage-reimbursed basis. We hope that more will do so.

One such was Brian Winn, Associate Fellow, for use at the Crypt School in Gloucester, while Clive Simpson put on a display of both *Spaceflight* and *JBIS* at the South Lincolnshire Astronomical and Geophysical Society Exhibition at the beginning of last October. He says that much interest was shown and he was able to encourage five people to join. Nicholas Kelly also acknowledged a generous supply of "give-aways," which he put to good use. Down under, from Invercargill in New Zealand, Lloyd Stridiron laid on a display both of SF and Society-orientated material. This included the Society's logo in prominent position, together with models of the Space Shuttle and copies of our magazines.

Magazines

The first issue of a new magazine, *Space Voyager*, which appeared early in 1982, contained mentions of the Society all over the place, including a long and well illustrated article by Alan Bond focusing on Daedalus.

Daedalus appeared yet again in an article called "The Three Suns of Centaurus" by Paul Patton which appeared in *Astronomy* for January 1982. This attracted a considerable amount of interest. *Starlog* for May 1982 ran an article on the evolution of the spaceship and, although our Society was not mentioned in the text, an accompanying "family portrait" of spaceships from 1831-1951 included three BIS designs. A very nice reference to the appearance of *Space Education* appeared in *Engineering Design Education* for Autumn 1981. It included the Society's name and address.

Returning to *Starlog*, the June issue expanded on May's with an extensive write-up on the original BIS spaceship, complete with a schematic of its layout. Also included was a reproduction of the front cover of the March 1979 "Interstellar Studies" issue of *JBIS*.

Sky & Telescope for December 1981 contained a piece called "Starscapes Near the Speed of Light". The four drawings used were all adapted, with acknowledgement, from *JBIS*.

Home News from Abroad

Also abroad, the *Peninsula Times Tribune* of 6 November 1981 contained a statement from Eric Burgess, quoted as "founder of the British Interplanetary Society", to the effect that he was confident NASA will ultimately chart more journeys to the planets and regain international leadership in the race to the stars.

Radio and TV

Andy Wilson banged the Society drums on the BBC Radio 4 "World Tonight" programme on 1 March discussing the Soviet Venera 13 landing on Venus. Tim Furniss (Fellow) was not far behind when he gave BIS national and provincial broadcasting exposure in STS 3 previews and reviews on his monthly spot on BBC Radio 1's Tony Blackburn's Weekend Show; also on Radio 1's B.15 programme and London's Capital Radio Breakfast Show and lunchtime "First Report".

Meanwhile, BIS members Anthony Kenden and Phil Clark were involved as advisors on a BBC programme about reconnaisance satellites, while Mat Irvine acted as visual effects designer.

Mentions on Book Jackets

Paul Barnett tells that his book "A Directory of Discarded Ideas" (written under his pseudonym John Grant) mentions his Associate Fellowship of the BIS. He adds that:

What's really impressive, though, is that in the publicity tour for the book several of the interviewers picked up this point, so I was able to plug the BIS on the air and in the press. One of the programmes concerned was a World Service broadcast with an international audience of about 50 million; another a BFBS programme with about 20 million listeners (one of whom was, incidentally, David Attenborough, who was in the control room waiting to be "done" after me.) I took care to stress that the BIS was a learned Society, so with any luck the publicity may do the Society some good!

David Baker's new monster book "The History of Manned Spaceflight" quotes him as a Fellow on the fly-leaf. The same is done on the back page of "The Story of the Space Shuttle", written by Tim Furniss.

British Aerospace News for November 1981 commenting on Ken Gatland's "Illustrated Encyclopaedia of Space Technology" mentioned him as a past President of the BIS, while the *Evening Mail* (both Birmingham and London editions) of 7 November 1981 ran a long piece on artist David Hardy, mentioning that he had chosen a collaborator "through his contact with the Interplanetary Society."

"Red Star in Orbit" by James Oberg described him as a Fellow of the Society and also gave the Society's name and address in an appendix. As something of a spin-off, several mentions of the Society from this book appeared in extracts from it in *Space World* for September 1981.

Up in Front

From time to time visitors ask why the name of the Society on the front of our HQ has been fixed at first-floor level when it would, clearly, be more advantageous to have it at the top-floor level, in which event it could also be clearly seen by the hundreds of thousands of passengers using the railway line opposite.

The answer is that the Local Authority would only grant permission for the sign to appear at the lower level. We also wanted an illuminated sign, with a softly-defused blue background. This would not only look discrete but also very attractive. Unfortunately this, too, was disallowed.

SPACE EXHIBITION

The Society was represented by the Executive and Assistant Executive Secretary at the opening of an exhibition of space photographs, "The Camera in Space" displayed at the Kodak Museum in Harrow, Middlesex and prepared by H. J. P. Arnold, a Fellow of the Society. The exhibition, covering the major space imaging systems and their practical applications, was opened by Constance Babington Smith, an expert interpreter of aerial photographs who uncovered evidence for the V-1 and V-2 weapons.

H. J. P. "Douglas" Arnold at the opening of an exhibition of space photographs (see story on this page). Mr. Arnold will be one of our speakers at Space '82 in November.

PHILATELIC NEWS

Members interested in philately who read of the Society's approach to the Post Office proposing special commemorative Space stamps for issue on the occasion of the Society's 50th Anniversary might be interested in their reply.

The idea stemmed originally from an announcement of Post Office interest in proposals to commemorate suitable UK Anniversaries. The Council's response was that, although wide interest in Space stamps exists throughout the world, opportunities to promote UK achievements had been woefully neglected and should be rectified. Many suggestions for an excellent series sprang readily to mind. There was the initial concept of Geostationery Satellites for communications purposes by Arthur C. Clarke; the Goonhilly Down Station would have publicised the initiative of the Post Office itself. There were historical subjects such as the work of William Congreve or, in humorous vein, the Golightly Rocket. In terms of technology there was the Blue Streak and Europa launchers, the X4 (Miranda) satellite whose achievements have been greatly under-estimated, besides many successful UK scientific satellites. The Society itself also pioneered much original work in early concepts of astronautics, described fully in its recent publication *High Road to the Moon*. No doubt, other similar ideas will occur to members which could be transformed into exquisite postage stamps.

The reply from the Post Office, unfortunately rejecting these ideas, included the following comment:

Our aim is to produce representative and interesting selection of subjects that lend themselves to good stamp design, pleasing to the public and to the philatelic market in this country and abroad.

It is hard to see how Space stamps fail to meet these criteria with a resounding plus!

The stamps actually chosen by the Post Office for 1982 include "Gardens", "British River Fish", and "British Fairs", none of which appear to mark any anniversary!

CHANGES TO BYE-LAWS

The Council, in consultation with the Society's Solicitors, has now adopted some Bye-Law changes to improve the arrangements for Council elections. These changes have been made in the light of experience over past years with the aim of ensuring that members are provided with the greatest freedom of action in expressing their will in such matters. These changes involve the substitution of the following new Bye-Law 24.

24. (a)

(i) Where the number of candidates nominated exceeds the number of vacancies required to be filled, election to the Council shall be conducted by a postal ballot as hereinafter provided and not otherwise.

(ii) Draft Ballot Papers shall be prepared and submitted to the Council for approval.

(iii) Immediately following the Annual Ceneral Meeting (or so soon thereafter as is practicable in the circumstances) the Executive Secretary shall send a Ballot Paper to each member of the Society.

(iv) The Ballot Papers shall be delivered or returned by post to the Executive Secretary at the Registered Office of the Society on or before 31st January in the calendar year following that in which the Annual Ceneral Meeting was held which date is hereby set as the day fixed for the determination of the result of the election and no account shall be taken of any papers received thereafter.

(v) A candidate may withdraw from the election at any time before the day fixed for the determination of the result of the election by delivering or sending by post to the Executive Secretary at the Registered Office of the Society a written notice of withdrawal signed by him.

(vi) If a candidate should die, withdraw under the last preceding paragraph, or be otherwise unable to stand, votes cast in his favour shall be valid and count for him but so that if such a candidate should secure enough votes to be elected to the Council the position which he has secured on the Council shall be deemed vacant and the powers of the Council in the Articles to appoint members to fill casual vacancies shall come into operation if the Council shall deem it fit.

(b)

(i) Ballot Papers shall contain details of the name and other relevant information concerning each member seeking election set out in the form and manner determined by the Council.

(ii) The Council shall pay regard to the requirement that it be well-informed over the complete range of the Society's interests and that its membership should include those most qualified to serve and shall indicate to members on the Ballot Form the names of those, which, in its opinion, are best able to undertake such tasks.

(c)

No election shall be in any way invalidated:

(1) By virtue of the fact that any member shall have been unable to vote on account of the date on which his voting paper was received by him.

(2) The receipt by any member of a Ballot Paper which is faulty or incomplete.

Provided that:

(i) such member may require that his faulty or incomplete Ballot Paper be exchanged.

(ii) the Council may resolve that such elections have been improperly conducted and the result thereof shall be void if the numbers of faulty or incomplete Ballot Papers returned are sufficient to have any material effect upon such result.

(d)

(i) If any Member of the Council or any Committee set up as hereinbefore provided holds any office, place of profit or other position with any organisation as a result of which a conflict of interest might foreseeably develop between the interests of the Society and such other organisation, or is in any other way interested in any organisation or body whereby such a conflict might arise, he shall declare the nature of his office, place of profit, position or other interest by written notice to the first meeting of the Council or Committee (as the case may be) next after he becomes aware of the possibility of such a conflict.

(ii) Where any person has given notice or is otherwise interested within the meaning of paragraph (a) above, he shall immediately withdraw from any meeting at which it is likely that matters will be discussed which relate to or could affect his interest.

(iii) Where any person does not withdraw as required above, his vote shall not be counted, nor shall he be counted to decide if a quorum is present."

The Council considers that all the above changes are in the best interests of the Society and will prevent any encroachment upon the rights of members. The reasons behind the changes are as follows:

By-law 24(a)

This bye-law as now drafted ensures that a candidate for election who receives only a minimal number of votes is not fortuitously elected through the death or withdrawal of an otherwise successful candidate.

Bye-law 24(b)

The Council has decided to adopt the practice of an increasing number of organisations nowadays by indicating on Ballot Papers each year those candidates which they recommend to the Society at each Annual Ceneral Meeting. Such a step has been frequently urged by members in the past because the considerations which determine who might best fill such posts are not immediately apparent from the Ballot Papers.

Bye-law 24(c)

The purpose of this bye-law is to ensure that no election can be in validated on minor technical grounds and the clearly expressed intent of members thereby thwarted.

Bye-law 24(d)

Both Council and Committee members should be free of any other office or commitment which could lead to a conflict of interest and might prevent them from acting in the best interests of the Society. This bye-law therefore makes necessary disclosure of such conflicting interests and requires withdrawal from meetings where such conflict may arise.

SOCIETY REPRESENTATION

The Society was officially represented by our Executive Secretary, Len Carter, at a Reception put on by His Excellency, Ambassador Louis, in Honour of Dr. Ceorge A. Keyworth II, Science Advisor to the President of the United States.

Other Space Cuests included Professor John Allen, a former Member of the Council, and Dr. Cary Hunt from University College, one of our Space '82 Speakers.

OBITUARIES

We are very sorry indeed to record the death of James C. Strong (Fellow), one of the Society's pre-War members. James was internationally known as an author on astronautical topics with a special interest in interstellar travel. He presented several lectures to the Society. His books included "Search the Solar System" and "Flight to the Stars". At the time of his death he was working on two further manuscripts, "Marriner of the Heavens" and its sequel.

We also regret to record the death of Thomas Ashcroft, a long-standing American member of the Society, recently upgraded to Fellow.

DAN DARE STRIKES BACK

A fascinating talk on the theme of "Man's Journey into Space: 1950's Style" was given by Adrian Perkins at the Society's Headquarters on 11 March. A graduate chemical engineer, Adrian has been a member since 1967. In the 1960's he was also a founder member of the Dan Dare Appreciation Society (now reconstructed as the Astral group), and he brought to bear the full range of his interests in giving his talk on the 1950's explosion of interest in space fact and fiction.

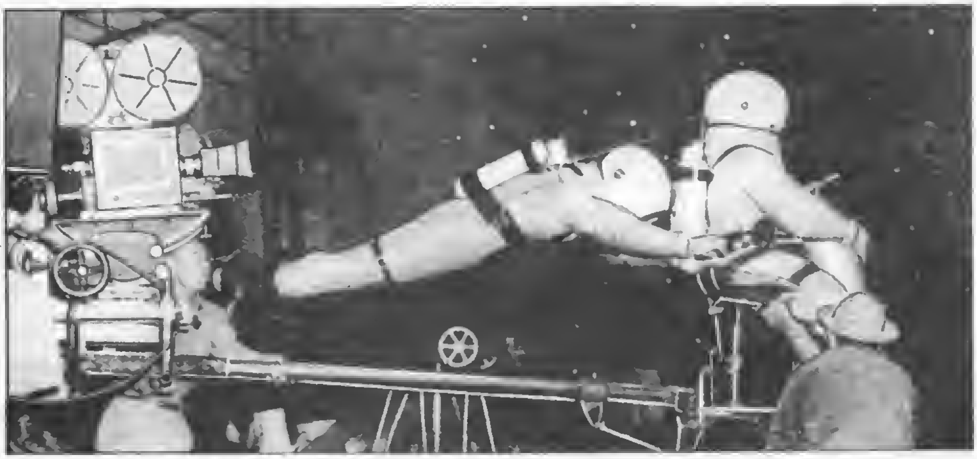
His talk was something of a "media event" – it began and ended with sound montages (Apollo 11, Journey Into Space, Thus Spake Zarathustra), and was accompanied by 90 slides delivered, at times, at a breathless rate.

Part of his thesis was that interest in spacc technology is due largely to the popularizing influence of science fiction and fictionalised accounts: he gave out copies of Alan Farmer's November 1975 *Spaceflight* article "Just Good Friends" to illustrate his point, and quoted liberally from the science fiction of the 1950's as much as from the fact.

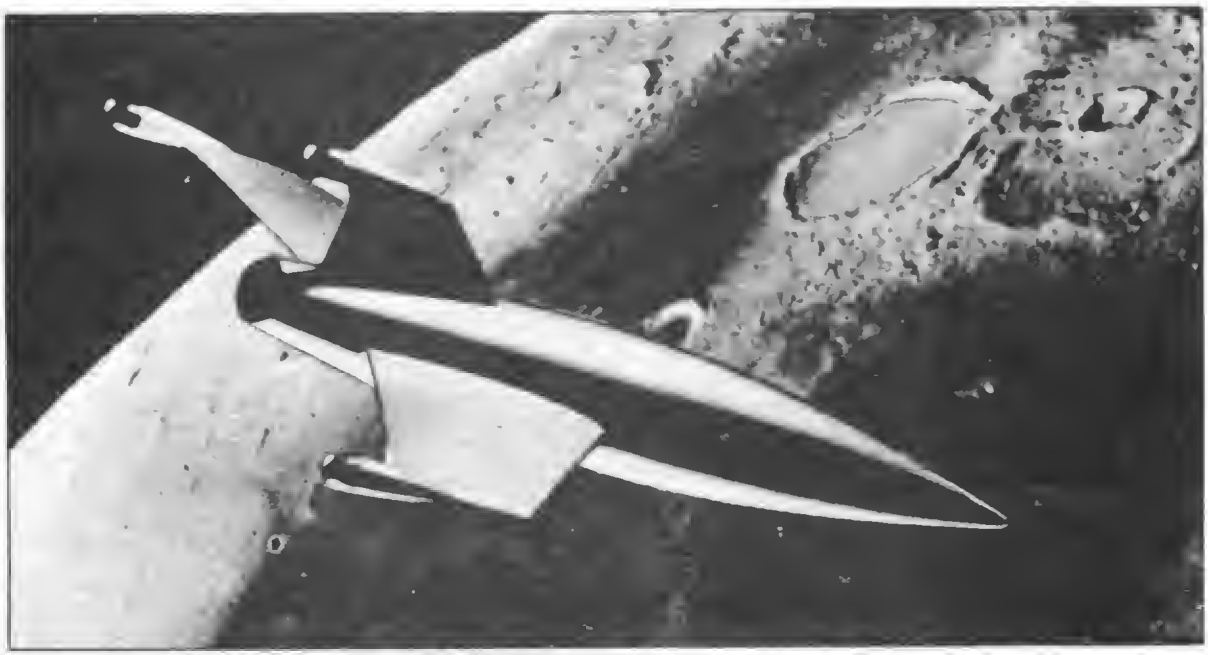
Here was a cavalcade of sights and memories that brought a nostalgic twinkle to the eyes of those who were young (or young at heart) in the 1950's. The slides and words reminded us of von Braun and his V-2s, and of von Braun as the populariser of space exploration. The pictures from Colliers, drawn by Bonestell, from von Braun's designs, started a movement. There were also stills from "Destination Moon'. Looking somewhat dated now, the film at the time was hailed by the experts (BIS included) as a great step forward in realism; Bonestell again, but also Herman Oberth as technical adviser, and a Robert Heinlein story-line. Among the slides, of course, were samples of the beautiful full-colour illustrations from the Ley/von Braun books that followed on from the Colliers' work, notably "Across the Space Frontier".

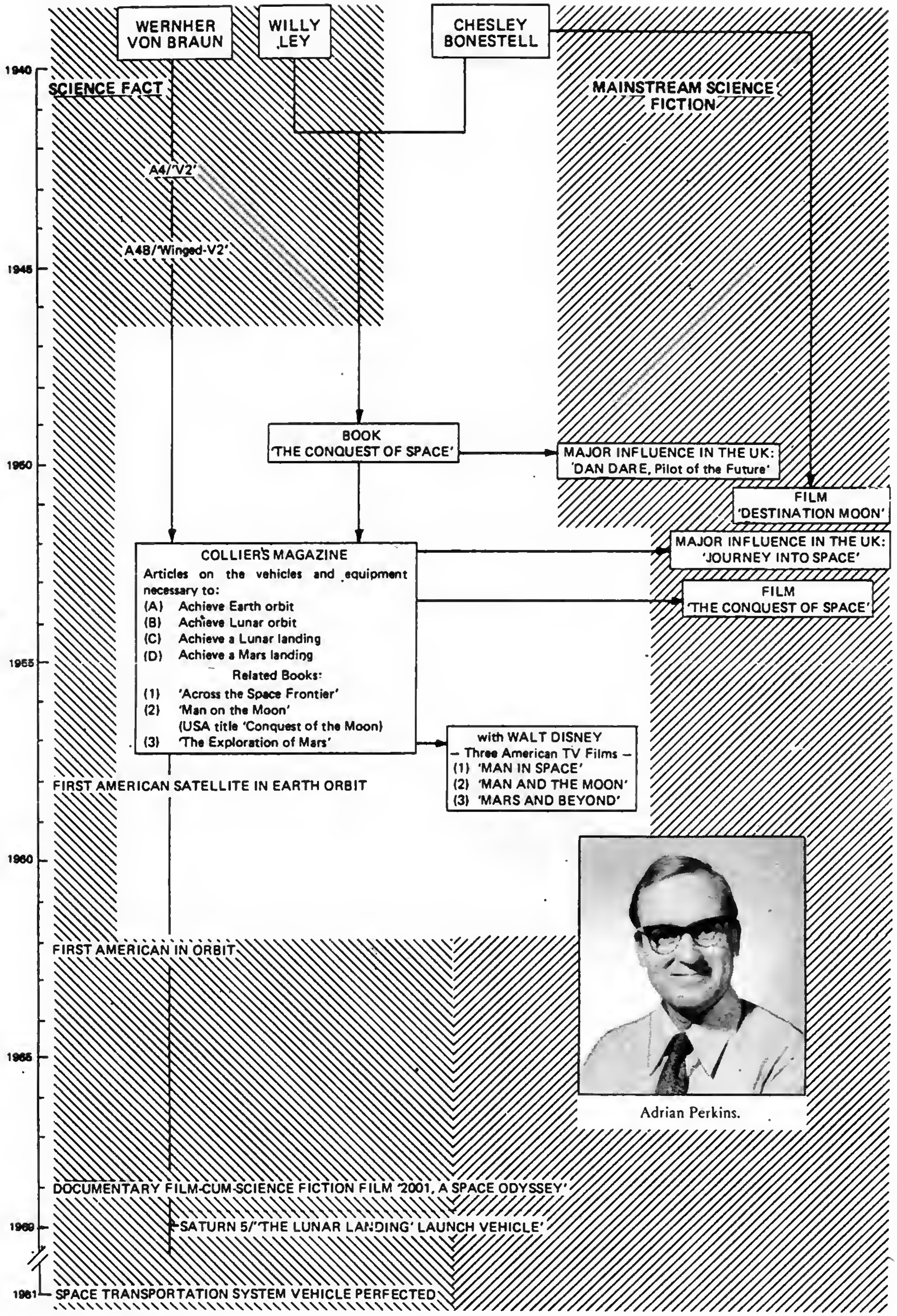
In the UK at the same time, Arthur Clarke was proselitizing. Here again were seen the Smith & Ross drawings from the "Exploration of Space", "Interplanetary Flight" and the *JBIS*. And, as you might expect, Adrian could not resist showing the hero of so many children of the time: Dan Dare and his exotic adventures in glaring colour, were still surprisingly undated (which could not be said for the BBC Radio series "Journey Into Space" of around the same time).

All these threads were followed through to the 1960's, and the real maturing of the Space Age. The talk ended with David Bowie's "Space Oddity", a fitting reminder perhaps, of how by the 1960's space was an accepted feature of everyday life, and not the subject of mirth it was before the "golden age" covered by Adrian Perkin's talk.



Left and below: the making of the feature film "Destination Moon", a very realistic representation of space travel (for the 1950's!). See the chart opposite, upper right.



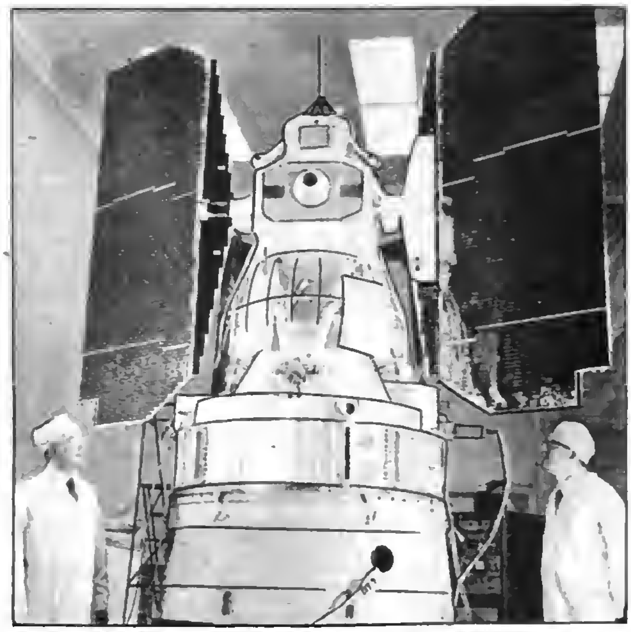


Adrian Perkins.

REMOTE SENSING MEETING

The Society was fortunate to have Dr. R. Harris of the University of Durham's Department of Geography to give its "Remote Sensing" study course talk on "Remote Sensing by Landsat and Weather Satellites" on 17 February. The talk was divided into five sections: Landsat satellites; weather satellites; applications of Landsat data; applications of weather satellites; and conclusions.

Landsat 1 was launched in 1972, followed by Landsats 2 and 3 in 1975 and 1978, respectively. This experimental programme of Earth resources satellites has been so successful that it has become a quasi-operational satellite system, with some users both relying on the data and investigating methods of handling the data on a regular basis. The Landsat programme began as the Earth Resources Technology Satellite (ERTS) programme, and the initiatives originated in the US lunar exploration programme of the 1960's. The multispectral scanner has been the most successful instrument. Data from this scanner have been used in a wide variety of mapping and monitoring applications. The next Landsat satellite (Landsat D) was due to be launched by NASA during the third quarter of 1982, and its data should provide exciting opportunities for examining the Earth in greater detail.



ERTS 1 (Landsat 1) was launched in 1972 to begin the series of highly-successful remote sensing satellites. Landsat 4 was scheduled for launch this summer. See the article by Dr. Harris on pp. 338-341 of this issue. *NASA*

Dr. R. Harris of Durham University.

The first US weather satellite (Tiros 1) was launched in 1960, and soon after the US initiated an operational weather satellite programme, developing Essa, Noaa and Tiros-N polar orbiting meteorological satellites. In addition, the Nimbus series provided space platforms for experimental sensors, and the US military interest in weather is catered for by the DMSP series. As well as these polar orbiting spacecraft, geostationary weather satellites have become very important, with the US GOES, European Meteosat, and Japanese GMS contributing to a global observing network set up in 1978/79 as part of the First GARP Global Experiment of the World Meteorological Organisation.

The applications of Landsat imagery were drawn largely from Northern England and from the Middle East. A set of slides showed examples of the types of data processing that can be achieved by analysing Landsat digital data on the IDP 3000 image processor at the Royal Aircraft Establishment, Farnborough. An example from Esfahan, central Iran, showed the use of windowing and zooming techniques, density slicing and classification to map agriculture in the oasis region. An example from the Durham area showed the way in which classification procedures can be used to map new suburban development.

Applications of weather satellite data are numerous, but the most common application is to assist forecasters in predicting the weather. Meteorological satellite data have also been used to estimate rainfall, particularly over remote areas, and to produce airflow maps by tracing clouds on a series of geostationary satellite images. Such techniques were illustrated by examples drawn from the Far East and from the Pacific.

The talk was concluded by a brief summary of remote sensing activities in Britain, some political considerations of the use of Landsat data, and comments about the future of meteorological and Earth resources satellite programmes in the 1980's.

AN APPEAL FOR ILLUSTRATIONS

We constantly need space pictures to accompany articles, historical and otherwise, to appear in *Spaceflight, JBIS* and *Space Education*.

In view of the difficulty in obtaining these we would be pleased to hear from any reader having illustrations which they would like to give us for Editorial use. Many pictures cannot be used immediately but are invaluable to fall back on whenever suitable articles come along. For this reason we are seeking pictures for permanent retention. Of greatest interest to us are pictures which have not hitherto enjoyed wide publicity or circulation, rather than those which have already been widely published.

The type of pictures we would like include photographs, cut-away drawings and paintings of all sorts related to astronomy and space. We are just as interested in older space-related pictures as in the most recent developments.

If you have any items of this nature which you would like to donate, please send them directly to the Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ.

Continued from inside front cover

Reception

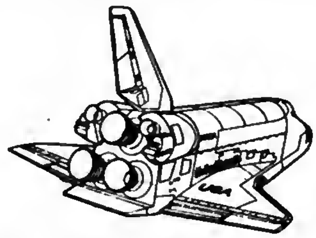
A reception will be held, followed by dancing. It will be a chance for everyone to get to know each other and to mingle with our distinguished Guests and Speakers. Martin Fry, Space '82 organiser, will welcome all to the "weekend" and Len Carter, our Executive Secretary, will invite participants to "Meet the Society". It will be a most interesting evening.

Accommodation

Brighton presents a wide range of accommodation for visitors, ranging from luxury and splendour to the more homely charms of Guest Houses. We can supply a brochure describing all of the hotels and their facilities. All you have to do is fill in a form and send it to Brighton Corporation, together with a small fee of 75p. They will do the rest, finding accommodation within your price range.

Registration

Registration will take place at the entrance to the Foyer Hall, where our meeting will be held, in the Brighton Conference Centre. Refreshments during the weekend will be available in the foyer and there will be an adjoining bar serving snacks. Additionally, full restaurant facilities will be available in the Centre itself for those not wishing to venture out of doors!



How to Apply

Registration forms are available from the Executive Secretary now. Applicants will receive the latest schedule of events (being updated continuously), a brochure of Brighton's facilities, a form for applying direct to Brighton Corporation for accommodation, and other explanatory material. Participants will also receive a detailed Space '82 brochure on arrival as a special souvenir. It will contain photographs and details of all the Speakers.

Please enclose a 20p stamp with all applications.

OUR GALAXY OF SPEAKERS

Patrick Moore	Astronomer and TV Presenter.
Erik Quistgaard	Director-General, European Space Agency.
T. O. Paine	Former NASA Administrator and President of Northrop Corporation.
M. S. Longair	Astronomer Royal for Scotland.
R. F. Freitag	Deputy Director of Advanced Programs, Office of Space Transportation Systems, NASA
G. E. Hunt	Planetary Scientist; Voyager and Pioneer Principal Investigator.
Reg Turnill	Space Correspondent.
R.M. Jenkins	Giotto Chief Project Engineer, British Aerospace.
R. Reinhard	Giotto Project Scientist, ESA.
G. M. Mueller	Former NASA Associate Administrator.
W. I. McLaughlin	Mission Design Manager for the Infrared Astronomical Satellite; Supervisor of the Inner Planets Trajectory and Mission Design Group; Jet Propulsion Laboratory.
E. S. Mallet	Director of Applications Programmes, European Space Agency.
C. R. Turner	Technical Secretary, Eurospace.
D. W. Hughes	Planetary Scientist.
H. J. P. Arnold	Director of Space Frontiers Ltd.
R. C. Parkinson	Superintendent of the Propellants, Explosives and Rocket Motor Establishment. Author of "High Road to the Moon".
P. A. Penzo	Planetary Scientist.
P. A. Swan	USAF Major.
B. I. Edelson	NASA Associate Administrator for Space Sciences and Applications.
A. R. Martin	Scientist, co-author of Project Daedalus study.
R. M. B. Shelton	British Aerospace.
M. Rees	Director of the Institute of Astronomy at Cambridge.
Olof Lundberg	Director General of INMARSAT.

SPACE '82 T-SHIRTS

Eye-catching T-shirts carrying the colourful Space '82 logo are now available. The 9 in diameter red, green, blue and black logo is printed on the front against a white background. Three sizes of these T-shirts (34-36", 38-40", 42-44") are available at a cost of £4.50 for UK and £5.00 ($11.00) for overseas, post free.

STOP PRESS

We are pleased to announce that Deke Slayton, one of the original seven Mercury astronauts, has accepted our invitation to Space '82.

Deke, who flew in space as an Apollo-Soyuz astronaut in 1975, was closely involved with the US manned space programme from Mercury to the Shuttle.

SPACEFLIGHT

Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 27/29 South Lambeth Road, London SW8 1SZ Tel: 01-735 3160

Correspondence and manuscripts intended for publication should be addressed to the Editor, 27/29 South Lambeth Road, London SW8 1SZ.

Opinions in signed articles are those of contributors and do not necessarily reflect the views of the Editor or the Council of the British Interplanetary Society, unless such is expressly stated to be the case.

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Discussion
Theme: **SOLAR SAILING**

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London SW8 1SZ, on **22 September 1982**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

37th Annual General Meeting

The 37th Annual General Meeting of the Society will be held in the Kent Room, Caxton Hall, Caxton Street, London SW1 on Saturday **25 September 1982**, commencing 3.00 p.m.

Details of the Agenda appeared in last month's *Spaceflight*.

33rd IAF Congress

The 33rd Congress of the International Astronautical Federation will be held in Paris, France from **27 September-3 October 1982.**

Theme: **SPACE ACTIVITIES OF THE YEAR 2000**

Members of the Society wishing to present papers are asked to notify Dr. L. R. Shepherd, Chairman of the BIS International Liaison Committee at Society H.Q. as soon as possible. Members wishing to present papers to the IAF Student Conference must submit them through the Society.

Film Show
Theme: **STEPS TO THE MOON – 1**

A series of film programmes to sketch the story of man's Exploration of the Moon. The first will be screened at a meeting to be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **6 October 1982**, 7-8.30 p.m.

The programme will include the following:

(a) Destination Moon — The Story of Project Ranger
(b) Close Up — A Look at Lunar Orbiter
(c) Project Apollo: Manned Flight to the Moon
(d) Steps to Saturn
(e) Landing on the Moon

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

First Night

An opportunity for new members of the Society (and interested guests) to meet Members of the Council and Officers of the Society will occur on **13 October 1982**, at the Society's HQ Building, 27/29 South Lambeth Road, London, SW8 1SZ, 7.00-9.00 p.m.

Our first two meetings have proved so popular that a third informal evening has been arranged when members can hear about the History and Activities of the Society, see a space film and have an opportunity for a short guided tour of the Building.

New members, or those who have not previously attended any Society function, who would like to attend are invited to apply in good time, enclosing a reply-paid envelope.

Lecture
Title: **SOCIAL AND PHSYCHOLOGICAL ASPECTS OF LONG DURATION SPACE FLIGHT**

by Prof. B.J. Bluth
California State University

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **18 October 1982**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Space Systems Conference
Theme: **THE SPACE TRANSPORTATION SYSTEM**
A Review of its Present Capability and Evolution

A three-day meeting to be held in Washington, D.C. USA on **18–20 October 1982**, sponsored by the AIAA, AAS, NSC, DCLR, JAS and cosponsored by the BIS.

Subject areas to be covered include:

(a) The Space Shuttle Orbiter
(b) Orbital Transfer Vehicles
(c) Reusable vs. Expendable Launch Vehicles
(d) Man's Role in Cround and Flight Operations
(e) User Needs for a Space Truck
(f) The Orbital Facility Applications

Intending registrants should write direct to: Mrs. C. D. Trudell, Mail Station 14-1, McDonnell Douglas Astronautics Company, 5301 Bolsa Avenue, Huntington Beach, California 92647, USA.

Study Course
Title: **UPDATING QUASARS**
by Dr. R. Carswell
Observatorio Interamericamo De Cerro Tololo

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **20 October 1982**, 7.00-9.00 p.m.

Please note that the date given is provisional and may change.

For details on joining the "Update Your Astronomy" Study Course, see the note in last month's Notices. Since all of our speakers are working astronomers, it may be necessary occasionally to change the sequence of lectures.

LIBRARY

The Library will be open to members from 5.30-7.00 p.m. on each of the following dates:

6 Oct. 1982	20 Oct. 1982
27 Oct. 1982	17 Nov. 1982
24 Nov. 1982	1 Dec. 1982

While every effort will be made to adhere to the published programme, the Society cannot be held responsible for any changes made necessary for reasons outside its control.

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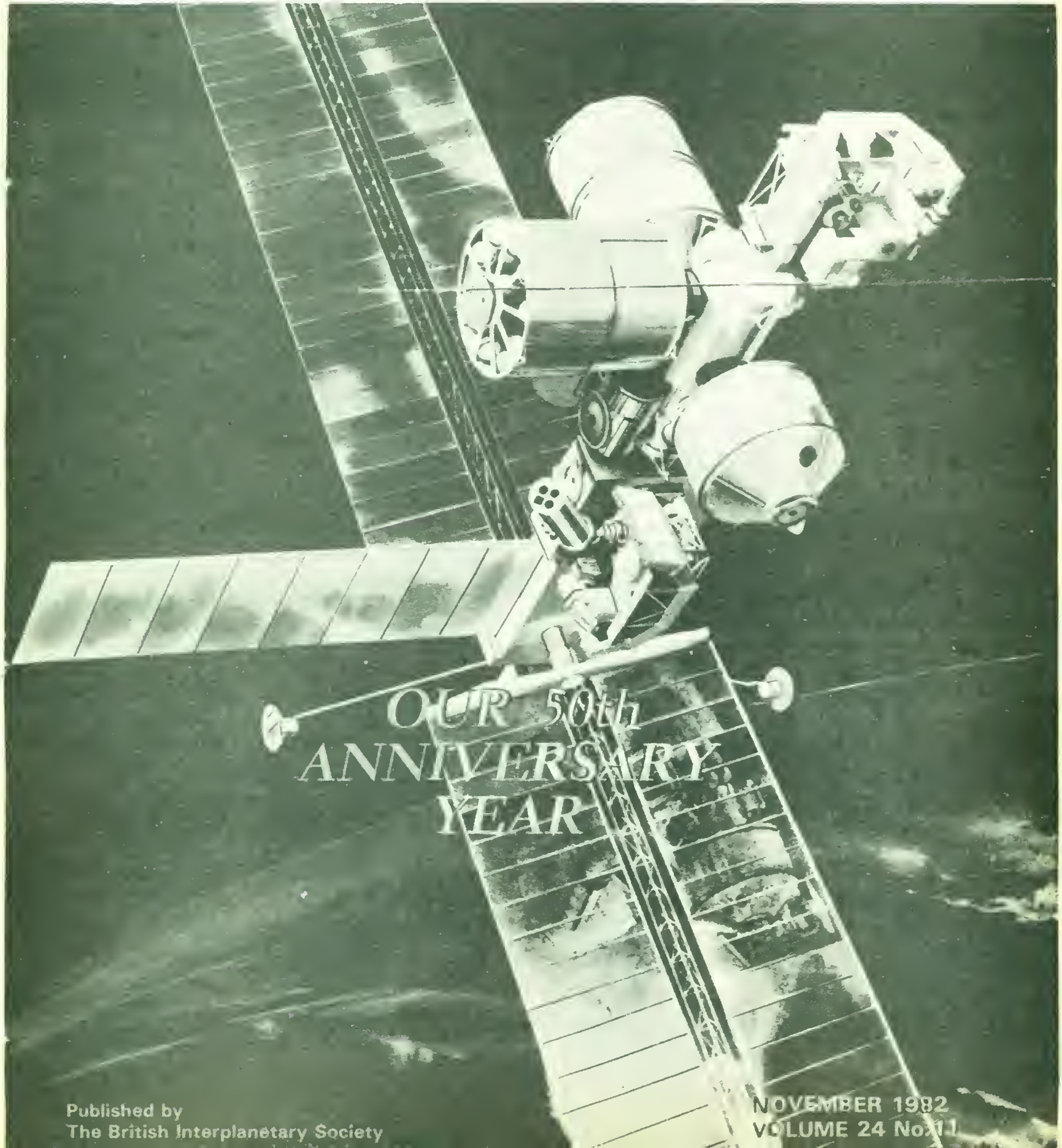


Published by
The British Interplanetary Society

NOVEMBER 1982
VOLUME 24 No. 11

JOIN US AT BRIGHTON 12 – 14 NOVEMBER FOR

SPACE '82 A VISION OF THE FUTURE


Deke Slayton, astronaut.


Erik Quistgaard, Director-General of ESA.


Bob Freitag, NASA Space Station Task Force.


Patrick Moore, astronomer.

Space '82 provides an excellent opportunity for Members and their guests to meet the people making space history. Top speakers from the world of astronomy and astronautics will present lively views on how Mankind will expand into the Universe and what benefits we can expect.

Our speakers will provide a comprehensive view of what is now being planned in the US and Europe. Bob Freitag, Deputy Director of NASA's Space Station Task Force, will reveal NASA's thinking on space projects for the future.

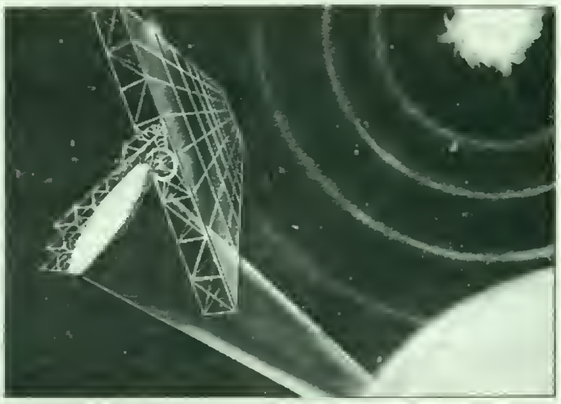
The Shuttle provides the path to the exploitation of space. Ex-NASA Administrator Tom Paine and Raefe Shelton of British Aerospace will take on the task of reviewing space industrialisation. Burt Edelson, just appointed as NASA's Associate Administrator for Space Sciences and Applications, will consider that vital topic of "World Space Communications".

A particularly interesting session will be held on the theme of the 1985/86 return of Halley's comet. Probes to Halley will be launched by Europe, the USSR and Japan in an effort to answer fundamental questions about the early history of the Solar System.

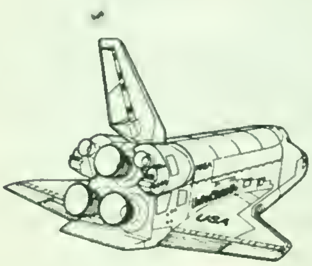
Patrick Moore and Bob Parkinson will, respectively, discuss Mars and the Moon, with Bob emphasising just how attractive a return to our celestial neighbour is. Garry Hunt and Paul Penzo will concentrate on different aspects of Solar System exploration.

These are just a few of the topics planned for Space '82. Details on joining this unique "space weekend" can be found on the inside back cover.


Exploration of the Solar System.



Halley's comet.


How NASA Sees the Future.

SPACEFLIGHT

A Publication of The British Interplanetary Society

Founded 1933 *Incorporated 1946*

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CONTENTS

386 **Prelude to the Space Age** *Kenneth W. Gatland*

393 **Space at JPL** *Dr. W. I. McLaughlin*

396 **MLR: A Shuttle Experiment**

398 **Space Communications**

402 **Space Report**

414 **News from the Cape** *Gordon L. Harris*

415 **The French Space Budget and Programmes (1982)** *Clive Simpson*

417 **Satellite Digest – 158** *Robert D. Christy*

419 **Book Notices**

422 **Society News**

425 **Society Meetings**

427 **Correspondence**

COVER

A space station reference concept from McDonnell Douglas, studied under contract to NASA's Marshall Spaceflight Center. This is a space platform design, developed to accommodate people, consisting of two solar arrays, a radiator, payload pallets and an airlock connecting two manned modules and a logistics module. Note the use of European-built Spacelab elements. The Director General of ESA and the NASA Administrator met in June and discussed European involvement in such a project.

MILESTONES

May 1982

20 NASA establishes a Space Station Task Force headed by John Hodge (originally from London) and Bob Freitag (a long-standing Fellow of the BIS). The aim is to produce a permanent US space station by the early 1990's.

22 An agreement is signed which will allow an Indian remote sensing satellite to be launched by the Soviets in the mid-1980's.

23 Progress 13 is launched to carry supplies to Salyut 7/Soyuz T-5. It docks with the station on 25 May. Konstantin Feoktistov, spacecraft designer and ex-cosmonaut, says that there is little difference between Salyuts 6 and 7.

June 1982

3 Cosmos 1374 is launched at 21.30 GMT from Kapustin Yar. It is reported to be a winged shuttle scale model; it reenters after one revolution at 17.5/98°E from a 230×191 km, 49.6° inclination orbit.

8 The Westar 5 communications satellite is launched by a Delta 3910/PAM from Cape Canaveral.

19 Meteosat 2, the European meteorological satellite, completes its first year in orbit. It continues to return visible, infrared and water vapour views of the Earth from its geostationary position at 0° longitude. The relaying of data from remote platforms has had to be continued by Meteosat 1 after the transponder in the new satellite failed to meet specifications.

24 The Soyuz T-6 crew, with the French cosmonaut Jean-Loup Chretien, is launched to dock with Salyut 6/Soyuz T-5. They return safely on 2 July.

27 The fourth Shuttle orbital mission, with astronauts Mattingly and Hartsfield, is launched. They land on 4 July at Edwards Air Force Base in California with President Reagan looking on.

29 Shuttle Orbiter *Challenger* leaves its production plant at Palmdale in California for the journey by road to Edwards Air Force Base. It is airlifted from the base soon after the landing of STS 4 on 4 July. *Challenger* will first fly in the STS 6 mission. An on-the-pad engine firing is planned for the first half of December.

30 General Beregovoi, commander of the Gagarin Space Training Centre, tells foreign journalists that two women, one a pilot-engineer and the other a flight engineer, are training for a Salyut 7 flight.

July 1982

3 The Marecs B satellite arrives at Kourou in French Guiana for launch by Ariane L5 on 10 September.

10 The Progress 14 resupply craft is launched to dock with Salyut 7 on 12 July.

16 The Landsat 4 remote sensing satellite is orbited by the first Delta 3920 vehicle.

30 The Salyut 7 cosmonauts make a 2 hour 33 minute EVA to retrieve experiments from outside the space station. The Salyut 6/Cosmos 1267 vehicle reentered the atmosphere the day before.

August 1982

2 Installation of the scientific experiments on the Spacelab 1 pallet is completed at the Kennedy Space Center. Power will be applied later this month.

19 Svetlana Savitskaya becomes the first woman since Valentina Tereshkova in 1963 to go into space. Serving as a researcher-cosmonaut aboard Soyuz T-5, she is accompanied by Leonid Popov and Alexander Serebrov. The crew will spend a week aboard Salyut 7 before returning in the Soyuz T-5 craft. Savitskaya, an experienced pilot, began training for her flight in 1980, well after NASA had chosen female astronaut candidates.

PRELUDE TO THE SPACE AGE

A BIS ANNIVERSARY

It is appropriate to publish this article on the influence of the BIS on the early development of space exploration as a prelude to entering our 50th Anniversary Year. The text is by Kenneth W. Gatland, based on his own records and those of Alexander Satin, former Chief Engineer of the Air Branch, Office of Naval Research, Washington, DC.

Left to right, A. M. Kunesch, L. J. Carter and K. W. Gatland examine a scale model of MOUSE (Minimum Orbital Unmanned Satellite, Earth) which preceded Project Orbiter in the early 1950's. On the wall are drawings of the German A9/A10 project of 1942 and (right) the BIS liquid propellant satellite launcher concept of 1948 with strap-on solid propellant boosters and expendable tanks. Kunesch holds a model of the inflatable balloon which MOUSE was to launch to enhance radar tracking.

Introduction

January 1982 marked the 30th Anniversary of a significant publication by the British Interplanetary Society: *The Artificial Satellite*. In this slim volume were recorded the ideas of a small group of international space enthusiasts who met at the historic 2nd International International Congress of Astronautics in London *six* years *before* the Sputnik age began. Although only a limited number of copies were printed, it is now clear that this publication helped to shape events which led to the first artificial satellites.

It is interesting to look back on the contributions of this select gathering which began with an address by Dr. L. R. Shepherd, then Technical Director of the BIS.

Shepherd said: "The rapid development of rocket propulsion during the past two decades has brought home to the public, and to the hitherto sceptical scientific and technical world, the possibilities of constructing vehicles capable of escaping from the Earth or of attaining a stable orbit around our planet. Astronautical enthusiasts have been aware of these possibilities for much longer, but have in the past held their views at the cost of a considerable amount of ridicule. The position today has so altered that we expose ourselves to no great danger, in the form of derision from the pundits and "authorities", when we come together in this international discussion of the satellite vehicle or space station . . ."

There followed a number of papers which included: "Interplanetary Travel Between Satellite Orbits" by Lyman Spitzer, Jr.; "Descent from Satellite Orbits Using Aerodynamic Braking" by Terence Nonweiler; "Meteor Hazards to Space Stations" by Michael W. Ovenden; "Minimum Satellite Vehicles" by K. W. Gatland, A. M. Kunesch and A. E. Dixon; "Establishing Contact Between Orbiting Vehicles" by R. A. Smith: "Landing of Spacecraft" by Edmund V. Sawyer (Pacific Rocket Society); "Biological Problems of the Earth Satellite Vehicle" (CAF, France); "The Optimum Satellite Freight Rocket" by H. Hoeppner (GfW, Germany); "The Foundation of the Space Station" by Guido von Pirquet (OGfW, Austria); "Start, Return and Landing of an Optimum Satellite Step Rocket" by H. Kuhme (GfW, Germany); "Optimum Orbit of a Space Station for Radar Tracking" by R. Merten (GfW, Germany); "Design Problems of the Space Station" by Herman H. Koelle (GfW, Germany); "Proposal for the Construction of a Space Station" by A. Pullenberg (NWGfW, Germany); "The Space Station as an Astronomical Observatory Site" by A. L. Joquel, II (Reaction Research Society, USA), and "How will the Space Station be Constructed?" by Rudolf Nebel (Germany).

It is now clear that several of these papers left their mark on history. One in particular was "Minimum Satellite Vehicles" which resulted from studies undertaken between 1948-51 in an attempt to bridge the gulf between satellite theory and engineering practice. This commemorative article records the background to this work and the events that followed.

Publication of *The Artificial Satellite* marked the Society's first venture into the book world. It was a 74 pp. booklet containing papers presented at the 1951 (London) IAF Congress in a special cover showing one of the visionary illustrations of the late R. A. Smith, then a leading member of the Council. The booklet was prepared and edited by Len Carter, our present Executive Secretary. One thousand were printed. The aim was to encourage interest and support for the idea of a small Space satellite, so over 500 copies of the booklet were sent, with a covering letter soliciting support for space developments, to every organization in America likely to be interested, with a smaller number distributed similarly in the UK. The balance were sold for the princely sum of 5/- (25p each at present prices post free.)

Sputnik Pre-dated

Two of the participants in this study [1-8], myself and Alan E. Dixon, at the time were junior members of the design team at Hawker Aircraft Limited, Kingston-upon-Thames, which produced the "Battle of Britain" Hurricane interceptor under Sydney Camm. The third contributor, Anthony M. Kunesch, was employed in the drawing office of Film Cooling Towers (1925) Limited in Richmond, Surrey.

Confirmation that we had influenced early US thought on the development of satellite launchers came in a letter from Alexander Satin, former Chief Engineer of the Air Branch, Office of Naval Research in Washington, DC, who pointed out that the early British study also pre-dated work on the first Sputnik [1]:

"Gentlemen, I have been planning for some time to write to you concerning your excellent paper, "Minimum Satellite Vehicles." in the book "The Artificial Satellite," London, 1951 - Proceedings of the Second International Congress on Astronautics.

May I inform you that this paper was used by me during 1952/54 to direct the first United States Space Project at the Office of Naval Research in Washington, DC, where I was Chief Engineer of the Air Branch, to an immediate application with available hardware in the United States.

I saw Mr. A. C. Clarke on 25 November 1952 at his home

Alexander Satin was born in Moscow on 29 June 1910. His family left Russia in 1919 and settled in Dresden, Germany. After studying at the University of Dresden, he received a Dipl. Ing. Degree and in 1937 went to the United States where he continued his studies at the Graduate Schools of the University of California, Berkeley, and New York University, Guggenheim School of Aeronautics. During World War II he worked on the first US rocket-propelled interceptor, the P-79, and later proposed "Project Navajo" based on Peenemünde data.

His extremely productive seven years as Chief Engineer and Staff Consultant of the Air Branch of the Office of Naval Research, Washington, DC, resulted in the initiation of many projects of advanced concept besides "Orbiter." The stated mission of the Air Branch ONR was to "maintain the country's scientific and engineering field of aeronautics, not equal to, but in advance of any other country." Its job was to "search out and encourage basic thinking" and to "sell" the ideas to other bureaus and departments which would "proceed with the development until a useful device, principle, or technique was produced."

While in this service, Mr. Satin pioneered many projects, including a family of winged VTOL and STOL aircraft, the "Flying Platform" and the "Aerodyne."

He also initiated numerous programmes, both study and development, in the field of rocketry, the best known of which are: the first completely throttleable rocket engine (developed by Reaction Motors, Inc.);

the "rocket-on-rotor" concept for helicopters; ducted rockets, and manned rocket aircraft, such as the Douglas D-588-3.

For his work and leadership while with the Air Branch of ONR, he received the Meritorious Civilian Service Award.

Mr. Satin tells us his hobbies are reading in fou. languages and music in a variety of forms. He is the nephew of the famous pianist and composer, Sergei Rachmaninoff.

- 88 Nightingale Road, Bounds Green, London. Mr. Clarke told me of your report, which I obtained the following day. When I analyzed your data I immediately saw that we could make a three-stage rocket with a very small orbiting payload, using hardware available to us at Office of Naval Research. This eventually became ONR Project "Orbiter" and was launched as "Explorer 1" in January 1958.

A recent Russian article, "Start into Space" - *NEW TIMES*, No. 40-77 by V. Gubarev, states: "In 1955 the Presidium of the USSR Academy of Sciences requested comments on the use of artificial Earth satellites." In 1954 Sergei Korolyov had written that "It would be timely at this present moment to organise a research division to pioneer a satellite." President Eisenhower announced in July 1955 the ONR Project. We could have launched it in 1956, but Project "Vanguard" temporarily replaced "Orbiter" for political reasons.

I had been working at ONR since 1949 on Space Program studies, and I gave the first US Space contract to Aerojet in 1952. " 'Sputnik' was just a ball from which the antennae of a transmitter jutted out. It carried *nothing* of the scientific instruments, the sundry sensors, traps and other gadgets that extra-terrestrial labs carry into Space now-a-days."
Thanks to your report, I proceeded to a three-stage rocket.

ALEXANDER SATIN
California, USA

The extract in the letter which refers to the initiation of Soviet satellite work appeared in *Pravda* on 7 December 1977. A longer extract reads:

In 1955 the Presidium of the USSR Academy of Sciences mailed to some hundred scientists the following circular: "Please comment on the use of artificial Earth satellites. What do you think they could carry? What experiments do you think could be conducted in space?" The answers varied. Some made definite proposals, but others wrote: "Not interested in fantasy; I visualize a space shot only in the year 2000," or "I don't see of what practical use artificial satellites could be." These remarks came from the pens of quite reputable scientists, and mind you, only two years before Sputnik went up. True enough, in 1955 that had seemed a pipe dream. I have quoted their replies not to reproach them, as many subsequently assiduously advocated space experimentation, but to show how far-sighted a genius Sergei Korolev was, when in 1954 he argued that it was quite possible to send up an artificial Earth satellite soon. "In my view," he wrote, "it would be timely and advisable at this present moment to organise a research division to pioneer a satellite and more thoroughly analyse the range of related problems."

Sputnik was conceived when the man who came to be known as the Chief Designer wrote these lines. However, it took another three years of "crazily intensive effort," as one of Korolev's team put it, for "the Simplest" as its creators dubbed Sputnik, to go up.

From the heights of today one might think there was nothing particular about Sputnik. Just a ball, from which the antennae of a transmitter jutted out. It carried nothing of the scientific instruments, the sundry sensors, traps and other gadgets that extraterrestrial laboratories carry into space nowadays. That was all to come - from the dog Laika carried by the next Sputnik and the study that was initiated of the Earth's ionosphere. What Sputnik demonstrated was that man, that science, now had fundamentally new opportunities to learn more about Nature and his habitat, the Earth.

Looking back across all those years, one is struck by the significance of one man's effort to establish an idea "whose time has come" and the small touches on the tiller that change

Table 1. Minimum Satellite Vehicle proposed in 1951 (Gatland, Kunesch and Dixon).

	Stage 1	Stage 2	Stage 3
Payload (kg)	2,880	210	0
Control (kg)	—	100	25
Structure (kg)	1,000	350	30
Pumps and engines (kg)	1,730	300	15
Propellants (kg)	11,190	1,920	140
All-up weight (kg)	16,800	2,880	210
Thrust (kgf)	33,600	5,760	210
Firing time (sec)	103	103	206
Acceleration (max)	6g	6g	3g
Length (m)	15.6	8.3	3.0
Diameter (m)	1.9		0.5
No. of engines	1	1	1

Alan Dixon explains a "stress" problem related to the expendable tanks of an early launch vehicle concept during a BIS lecture session at Caxton Hall in 1950.

the course of history.

First of all, the colossal inertia that had to be overcome to get people, even distinguished scientists, to take seriously the idea of putting a satellite into orbit. The frustrations which Alexander Satin and others encountered in Washington in the early 1950's were precisely the same as the BIS faced in Britain in trying to promote space activity.

Not only was it doubted that rockets could achieve the performance necessary to place man-made objects into orbit; something close to ridicule was poured on our efforts by engineering colleagues who considered we were wasting our time, even impairing our careers, by such extravagent and "useless" pursuits.

This problem was recognised at an early stage by the BIS which encouraged members to publish their results at international symposia and in established trade journals in order to reach the widest possible audience. A classic example was Arthur Clarke's memorandum on "The Space Station: Its Radio Applications" discussed by the BIS Council in 1945 and subsequently developed as an article for *Wireless World* [9].

As far as our studies of "minimum satellite vehicles" were concerned, official interest in Britain was nil.

Our aim in starting these studies in 1948 was precisely to discover the smallest class of vehicle which could result in a satellite. At Hawker's we were very conscious of the need to minimise structural and equipment weights in high-performance combat aircraft.

I well remember going down to the Royal Aircraft Establishment at Farnborough after World War II where a whole galaxy of German aircraft and missiles had been assembled for technical inspection. The V-2 rocket held special fascination and one was immediately struck by the structure with its circular frames, stringers and external skin (and separate tanks for liquid oxygen and ethyl alcohol propellants) which owed much to conventional aircraft construction techniques.

In our rocket studies we set ourselves three goals:

1. Evolve a more efficient rocket structure of light-weight construction.
2. Seek a more energetic propellant combination that might become practicable, say, in five years.
3. Improve the technique of multi-stage rocket construction.

Our first thought was to combine tanks and structure in the same envelope and much time was devoted to evolving a system of expendable tanks which would separate from the rocket as its flight progressed.

As I recall, the idea stemmed from two sources. One was the pre-war BIS study of a manned space vehicle capable of landing on the Moon which had a cellular arrangement of solid rockets that jettisoned in stages. The other was the work done at Hawker's during the War to increase the range of the Hurricane, Typhoon and Tempest by means of external, jettisonable tanks.

At first, cellular tank construction seemed the perfect answer, and tank segments were designed in some detail and subjected to preliminary stress analysis by Alan Dixon who worked across the partition from me in the Stress Department. Tony Kunesch, who had attended the same school as myself in Surbiton, also worked on the expendable tank idea, applying his considerable talent with the slide rule to some complex problems. One of the chief difficulties was that of arriving at realistic weight estimates for rocket engines, pumps, guidance and other equipment, all virtually unknown quantities in the late 1940's.

For a year or more our efforts were concentrated on the expendable tank concept. Then, one morning, Alan Dixon walked up with a suggestion of his own. "Why not make a thin-walled cylindrical rocket tank which retains its strength by internal pressure, like an elongated toy balloon? The idea had the beauty of simplicity and we began to rework the studies in the direction of conventional three-stage rockets of greatly improved performance.

Dixon recalls: "All papers known to us at this time had the same mistaken idea that rocket structures would have the same weight characteristics as aircraft structures and it was not surprising that their authors could never get the mass ratio right.

"The idea of using the internal pressure came about one evening when I was calculating some tank wall thickness requirements and found myself looking at answers that were telling me that if I picked the right combination of pressure and tank shape I didn't need any structure at all!

"I decided it was a bad evening and put the work away.

When I re-examined the calculations a few days later I found no mistakes and realised that stringers and frames were not required for a rocket structure. I remember thinking at the time: why has nobody else drawn attention to this?"

There was also the question of propellants. After considering a number of possible combinations we chose liquid oxygen and hydrazine as representing a promising, though largely untried, combination which seemed to offer reasonable chances for practical application "within five years."

Four examples of three-stage rockets were considered in the final study:

a. Without payload, for checking the orbital path and drag studies.
b. With 100 kg payload (research instruments and telemetry). Launch weight 62.4 tonnes.
c. With 100 kg payload, including additional control equipment. Launch weight 90.9 tonnes.
d. With same launch weight and allowance for control equipment as (c) but using expendable tank construction, the improvement in effective mass ratio due to expendable tanks permitting the payload mass to be increased to 220 kg.

Table 1. gives a breakdown of the smallest launcher example (a), which had a take-off weight of less than 17 tonnes. This would have the primary object of placing a body in a closed orbit, without payload, as a first approximation for the purpose of checking the orbital path by means of ground tracking. As the final stage of this vehicle would have particularly small dimensions (i.e. length 3×0.5 m diameter), it was suggested that an inflatable metalized "paper" balloon might be incorporated as a radio reflector, which could be attached to the rocket and inflated in space. From observation of the behaviour of the sphere, which might have a diameter of several feet, the density of the air in the outer atmosphere could be determined. As a further development, it was suggested that a small radio-beacon might be embodied in the final stage for position-finding, together with an instrument for measuring a single quantity (e.g. cosmic radiation), the data being incorporated in the rèturn signal. A maximum allowance of 4.5 kg was made for this equipment.

The paper containing these conclusions, "Minimum Satellite Vehicles," was presented at the 2nd congress of the International Astronautical Federation in 1951. It stressed how, by careful design, useful improvements could be made in the mass ratio (the ratio between the take-off weight and the dry weight). Consideration was given to the use of integral propellant tanks making use of pre-tensioning effects. It was emphasised that a properly constructed tank, with thin walls and hemispherical ends, could be made to act as an efficient load-carrying structure when full of propellants and pressurized. Further structural economy resulted from the elimination of stabilizing fins. Pivoting motors with gas-jet controls for the post cut-off phase were proposed as a means of stabilizing the ascent path.

The American Connection

Alexander Satin entered the picture in 1952 and, fortunately, he kept detailed diaries of the period. He recalls arriving in London at 2 p.m. on 23 November. "Our flight from Frankfurt was to go to Paris, but the Air Force DC-3 did not land in Paris because of fog." The next day was spent mainly visiting

First US space team at the Office of Naval Research (ONR), Washington, D.C., Ï7 March 1955. The project was ealled "Orbiter" and was later launched as Explorer 1. It was purely a Naval project started at ONR in 1952-53, with the US Army invited to provide the first stage, either Jupiter or Redstone. *Standing left to right*, Lt. Cdr. William E. Dowdell (USN Observatory); Alexander Satin (ONR); Cdr. Robert C. Truax (USN); Liston Tatum (IBM); Austin W. Stanton (Varo, Inc.); Fred L. Whipple (Harvard Observatory); Ceorge W. Petri (IBM); Lowell O. Anderson (ONR); Milton W. Rosen (NRL). *Seated, left to right*; Cdr. Ceorge W. Hoover, USN (ONR); Frederick C. Durant, III (A. D. Little); James B. Kendrick (Aerophysics Development Corporation); William A. Giardini (Alabama Tool & Die); Philippe W. Newton (DoD); Rudolf H. Schmidt (ABMA); Cerhard Heller (ABMA); Wernher von Braun (ABMA).

US Navy

the Admiralty (Capt. Lohman, Dr. Holmberg, Dr. H. Sutton, W. W. Sales, Harry Garner and others).

"I also visited the British Interplanetary Society, at first getting an obsolete address (21 Mann Street, London, SE17) before reaching the new BIS headquarters at 12, Bessborough Gardens near Westminster around 4 p.m.

"From the BIS I obtained the address of Mr. A. C. Clarke at 88, Nightingale Road, Bounds Green. I saw him on Tuesday 25 November at 5 p.m. and he suggested that I get a recent BIS publication, *The Artificial Satellite* [6]. I went to the store that Clarke had recommended and remember sitting ten feet high on a ladder trying to find that publication and being challenged by two young men because of the Rosenberg atom spy trials then underway in the United States.

"In the report I finally obtained I found the paper that Gatland, Kunesch and Dixon had presented at the 2nd Congress of the International Astronautical Federation the previous November. It was called 'Minimum Satellite Vehicles.'

"No information such as this report contained was available to me in the United States, as the RAND studies and the von Braun 1952 articles in *Collier's* magazine proposed grandiose schemes which would have taken impossible sums to accomplish [10]. RAND was concluding that a \$4 billion Space Station should be the initial step; and Wernher was contemplating huge rocket vehicles for sending men to the Moon and Mars*. Such money would never have been available to me at ONR or anywhere else!

"Looking at this British study I was completely surprised; we in the United States had already in existence all the hardware to put together such a three-stage vehicle.

"One has to realise the scientific climate that prevailed in 1952 regarding potential space research. Ridicule, contempt and insults were the only established attitudes. I remember especially Theodore von Kármán, who was then Chief Scientist of the US Air Force. He declined to talk about such 'unscientific nonsense.' And all the university professors were totally opposed to such work as being outside their sphere of interest.

"I was finally able to talk to Dr. Fred Singer on Thanksgiving Day, 27 November 1952 at the cold and unheated Office of Naval Research in London. He was totally non-commital and did not want to do any consulting work for ONR in 'Space'† as he was going back to the United States to become Professor of Physics at the University of Maryland. I was looking for qualified consultants but nobody was interested. I left London that night in the famous red smog attack and arrived in Paris by 'Golden Arrow' at 10 p.m.

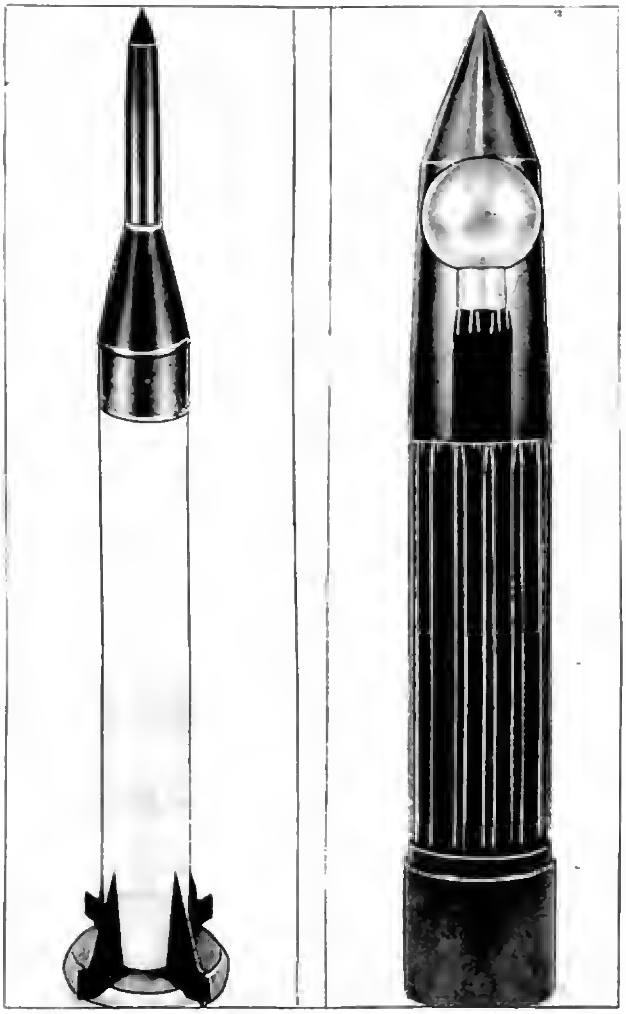
"When I returned to Washington I immediately looked into the possibility of restructuring our research effort with Aerojet along the lines of the Gatland, Kunesch, Dixon work. Without this study, there would have been no 'Orbiter' project as I would not have had the necessary information to proceed with the design of a very small satellite launcher. Only with this kind of information was I able to convince my project engineer that we should proceed with 10–15 per cent of the Aerojet funds available with a preliminary design for so small a vehicle."

It is clear that a positive objective had been set for a small satellite and this question exercised the minds of the ONR officials.

Significantly, further impetus for this work came from another quarter: the field of aviation concerned with high-performance aircraft.

Cdr. George Hoover, who played a key role in this endeavour, explains [12]:

"From the early results of the Aerojet-General study it became apparent that we knew little about the aeromedical problems of space flight, the re-entry effects, the launching and landing, and other areas for which sufficient data was available. It was also apparent that in order to keep abreast of aircraft design such as the D558-III, these data had to be obtained. Balloons were incapable of reaching the required altitudes and rocket sondes could only provide data over periods of minutes; the data required had to be measured over extended periods of time if it were to be truly useful. There was little doubt that the only solution to this enigma was an Earth orbiting satellite. As late as December 1953, team members of the NRL – the group that eventually produced the Vanguard satellite launcher – were still expressing doubt on the ability to achieve this critical objective" [11].



Project Orbiter – the only model that exists – was given to Cdr. Hoover by Dr. von Braun shortly after the decision was made to go ahead with the Loki rockets. At this time the project was highly classified and had three different code names. It was first called SLUG "because we were planning to place a 5 lb (2.26 kg) slug into orbit", writes Cdr. Hoover. "Wernher felt that this name was a bit repulsive so we then adopted BOX LUNCH since Wernher had promised the team a steak dinner and because of the delay in launch of the Redstone we were observing we all ended up with a box lunch. Fred Durant wanted to call it PROJECT ROSE (don't ask me why), but we finally ended up with ORBITER."

Enter von Braun

On 23 June 1954, Cdr. Hoover received a telephone call from Frederick C. Durant, then President of the International

* *See, for example, "Man on the Moon: The Journey,"* Colliers, *18 October 1952.*

† *Singer, however, was later to make his own significant contribution to the idea of a small scientific satellite in the MOUSE project.*

Astronautical Federation, who informed him that Dr. Wernher von Braun would be in Washington within the next few days. Mr. Durant indicated that a meeting could be arranged , and so plans were made for a conference at the Office of Naval Research. On 25 June 1954 Mr. Fred Durant, Mr. Dave Young of Aerojet-General, Dr. Fred Whipple, Dr. Fred Singer, Cdr. Hoover and other ONR personnel.

When the meeting opened, the first question Cdr. Hoover placed before the group was whether or not an official scientific satellite project was being conducted by any US agency or group. After some discussion it was agreed that although several studies had been conducted there was no officially sanctioned satellite programme. The second question then placed before the group was whether or not it was possible to launch an earth satellite within the next few years. In answer to this question, Dr. von Braun presented a plan for the use of existing hardware: a modified Redstone missile in combination with a cluster of Loki rockets which he had calculated could place a 5 lb (2.2 kg) satellite in a 200 mile (322 km) elliptical orbit. Following this presentation there was a great deal of discussion as to the value of such a small payload and whether a more sophisticated satellite should be considered. There was little disagreement about the need for an instrumented satellite, but the cold facts were that 5 lb (2.2 kg) was the maximum that could be orbited with a system which could be available in the immediate future without major development [12].

It was generally concluded that an inert 5 lb (2.2 kg) satellite could be used: 1. to obtain data regarding upper air density; 2. to establish baseline distances on the Earth; 3. to determine the ionization content of the atmosphere by making the satellite visible optically and electronically; 4. to establish the air density at these altitudes by observing orbital decay.

The group finally agreed that a Redstone and Loki upper-stage combination was capable of placing a small satellite in orbit, that the satellite could be scientifically justified, and that an Earth satellite project should be established as soon as possible, since considerable national prestige could be gained by placing the world's first man-made satellite in Earth orbit.

Following this meeting, a presentation was made to Rear Admiral Furth, Chief of Naval Research, in July 1954. The Admiral stated that he would approve the project if General Simon, Chief of Army Ordnance, would agree to a joint programme. On 3 August Hoover and von Braun discussed the subject with General Toftoy, Commanding General, Redstone Arsenal. Toftoy contacted General Simon who in turn met with Admiral Furth, and the project was approved. It was agreed that the Navy would manage the design, development, and construction of the payload, arrange for tracking facilities and logistic support, and record tracking and other data. The Army agreed to carry the responsibility for the Redstone modification, and development and construction of the Loki stages. The project was given the name "Orbiter."

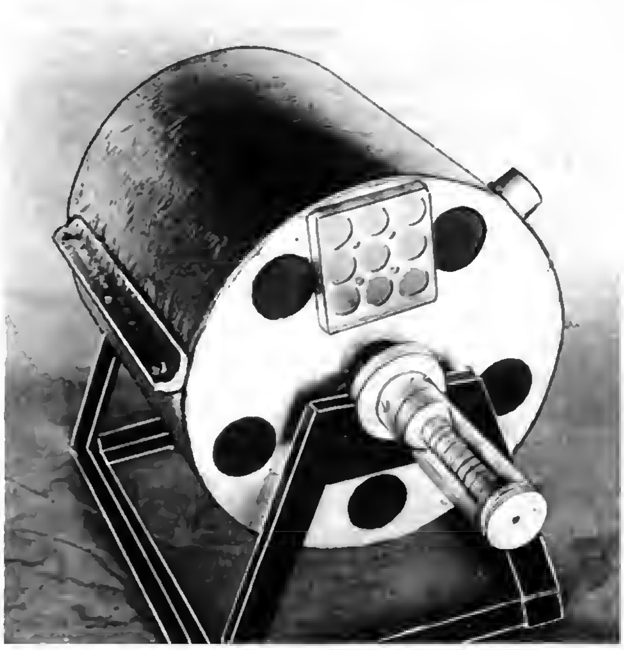
Three contracts were let by ONR in late 1954. The first, a satellite visibility study, went to the Varo Manufacturing Company, who had hired Dr. Fred Whipple as a consultant. This study was to determine the requirements for making the satellite visible by optical and electronic means. The second contract was awarded to Alabama Engineering and Tool Company for the design and development of the Loki cluster mount and guidance system necessary to place the satellite in orbit. The third contract went to Aerophysics Corporation to cover development of the Loki cluster. A fourth study, however, was planned with IBM to conduct development of the communication and reporting system. Wernher's right hand man on the project was Dr. Ernst Stuhlinger[13].

On 10 January 1955 the proposed satellite programme was presented to Mr. Donald A. Quarles, Assistant Secretary of Defense (R&D) as a first step in bringing the project to the attention of the Secretary of Defense. Following this first presentation, the US National Committee for the International Geophysical Year also requested that the National Science Foundation and the Defense Department support a satellite programme as part of the United States effort for the International Geophysical Year. The Naval Research Laboratory then submitted a proposal for a scientific satellite to support the IGY committee's request, and the USAF followed with a similar proposal.

In view of these events, the Defense Department formed a seven man committee under the chairmanship of Dr. Homer J. Stewart of the Jet Propulsion Laboratory-California Institute of Technology. Presentations by the Orbiter group, NRL and USAF were made to the committee and, by this time von Braun had decided to switch from the small Loki rockets to scaled down Sergeant rockets which would increase the Orbiter payload to 18 lb (8.16 kg) and at the same time reduce the total number of rockets required in the upper stage clusters.

Cdr. Hoover continues: "The decision of the Stewart com-

The MOUSE project. The influence of early British ideas on the evolution of American satellites today receives acknowledgement at the National Air and Space Museum, Washington, D.C. Professor S. F. Singer's MOUSE was first proposed at the 4th International Astronautical Congress in Zurich, 1953. The model was constructed by Singer in 1954 and includes some of the earliest solar cells produced by the Bell Telephone Laboratories. MOUSE would have weighed 45.4 kg (100 lbs) and would have included instruments to measure cosmic rays, interplanetary dust, and solar ultraviolet and X-rays. The satellite, powered by solar cells, was to be spun on its long axis, with its instruments carried on the rods projecting from either end.



mittee was, nevertheless, 4-to-3 in favour of the NRL paper proposal, and on 9 September 1955, a DoD directive was issued to proceed with the NRL project which was called "Project Vanguard". The history of what happened after Vanguard was established has been reviewed many times. It is sufficient to say that the Explorer 1 built by the Jet Propulsion Laboratory and placed in orbit by Dr. von Braun and his crew on 31 January 1958, did in fact use a cluster of 15 scaled-down Sergeants with a spin-stabilized guidance system that was first conceived in the Orbiter design. Although Project Orbiter in its original configuration was cancelled, the presentation made on 20 January 1955 to Mr. Quarles did accelerate events ultimately leading to the United States Space Programme."

"An assistant to President Eisenhower," Mr. Satin recalls, "was instrumental in having Orbiter scuttled, possibly because of von Braun's German background."

[At the time Vanguard was being promoted as a purely scientific project untainted by military association – Ed].

But fate, and the Soviets, were yet to play trump cards.

On 4 October 1957 Korolev shook the world by launching the world's first artificial satellite using one of his ICBM prototypes. America, still working on the "civilian" Vanguard for the ICY, was stung into action, but failed in the first attempt to place a small test satellite into orbit. Instead of taking off into space, the pencil-slim rocket toppled over and erupted in flames.

Von Braun's team, called in to rescue America's battered prestige, dusted off the ONR Orbiter project and produced a four-stage version of the Jupiter-C research rocket which put Explorer 1 into orbit on 31 January 1958 after only 80 days of work [10]. Fortunately, during 1956-57, the parts of the satellite launch system had been kept in store.

The stepwise progression to Orbiter-Explorer went like this:

- **1949–51** Preliminary studies at ONR, Washington, DC.
- **1951** RMI Proposal with Jimmy Wyld.
- **1951** Publication of "Minimum Satellite Vehicles".
- **1952–53** Aerojet study with recommendations for further progress including "minimum" satellites, Dave Young Project Director.
- **1954–55** "Orbiter" – General Toftoy and Wernher von Braun invited.
- **1955** President Eisenhower announces "Orbiter", 15 July.
- **1956** "Vanguard" replaces "Orbiter".
- **1957** Russia launches "Sputnik 1", 4 October.
- **1957** "Vanguard" fails on launch pad, 6 December
- **1958** "Explorer 1" launched, 31 January.

In further correspondence, Alexander Satin adds this footnote to history: "I am sure you are familiar with the expression 'not invented here' which rejects anybody else's ideas. For this reason many of the people involved will not remember your report after 25 years. You have probably noticed that in all the announcements from 1957 to 1978, ONR was never mentioned. Hoover and I left ONR in 1956-57 for California and Orbiter-Explorer was presented in 1958 to the media as an Army project.

"Looking back to my time at ONR it was a fabulous opportunity to do some really significant work. There was no similar organisation anywhere else. We had only six or seven officers and four civilians working on the initiation of new projects in the ONR Air Branch. The Army had no space research 'Requirement' and could not touch such 'far-fetched' and exotic things . . .

"The political aspects sometimes were vicious and VERY unpleasant. What amazes me today is how quickly we were able to get things moving from zero start to hardware – and in no small measure it was thanks to your report."

Dr. J. A. Van Allen (foreground) prepares the instrumented head of a Deacon sounding rocket during the 1952 Greenland Cosmic Ray Expedition. Six years later – thanks to the inspiration of MOUSE and Orbiter, and the subsequent work on Explorer – his instruments were to reach orbit leading to the major discovery that the Earth is girdled by radiation trapped by the magnetic field.

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SPACE AT JPL

By Dr. William I. McLaughlin

GALILEO ON TARGET

The writer Mark Twain once cabled a correction from Europe to the Associated Press, "The report of my death was an exaggeration." In a similar vein, the press has reported the end of the Galileo mission to Jupiter several times in the last year. Now, however, continued funding seems assured, and Galileo, along with the Voyager 2 encounters with Uranus (1986) and Neptune (1989), should form the backbone of JPL's interplanetary programme for this decade.

The basic plan of the mission (see also the July-August issue of *Spaceflight*, pp. 290–294.) is to insert a 1600 kg spacecraft into orbit about Jupiter after first deploying a 335 kg probe into the Jovian atmosphere. The orbiter will conduct measurements in the Jovian system concerning the planet, rings, and Galilean satellites, with at least 11 satellite encounters within 24 months after insertion into orbit about the planet. Some of these encounters, using satellite gravity-assist, will be as close as a few hundred km and will provide unmatched opportunities for determining the chemical composition and fine-scale structure of these bodies. Supplementing the optical imaging system will be an ultraviolet spectrometer, an infrared spectrometer and a radiometer for measuring temperature profiles, as well as several field-and-particle instruments. The Galileo Probe will carry instruments designed to measure the temperature, pressure and chemical composition of the Jovian atmosphere. The orbiter will provide a relay link communicating the probe measurements back to Earth.

The May 1985 launch will involve an Air Force Inertial Upper Stage (IUS) rather than the wide-body Centaur that was originally planned (the Shuttle is to be used for the initial launch phase). In order to compensate for the loss in capability resulting from this change, two actions are being taken: (1) a kick stage will be added on top of the IUS, and (2) the trajectory will incorporate a gravity assist from Earth. This type of trajectory, termed a ΔVEGA=ΔV-Earth-Gravity-Assist, features a loop in the inner Solar System of approximately two years' duration (shaped by a velocity change or ΔV) which is followed by a very close, 200 km flyby of the Earth in order to be boosted into the Earth-Jupiter leg of the trajectory. Arrival at Jupiter is scheduled for late 1989 or early 1990, depending upon the exact trajectory which is selected. JPL's Mariner 10 mission to Venus and Mercury was the first mission to employ gravity-assist techniques.

It now appears that the Centaur will be used after all—Ed.

THE WHEEL TURNS

With the advent of a significant amount of Department of Defense work at JPL, it is clear that the Laboratory is entering a new phase in its development. It is perhaps useful to view this most recent phase in the context of the history of the Laboratory, which covers almost 50 years.

JPL is part of Caltech, and from Caltech it grew. In 1926 the Guggenheim Aeronautical Laboratory, California Institute of Technology (GALCIT) was founded and became a leading centre for aeronautical research under Dr. Theodore von Karman. Ten years later some work on jet and rocket propulsion began, and the theoretical aspects of this work were supplemented by testing of rocket engines in the Arroyo Seco, a few miles from the Pasadena campus and at the site of the present Jet Propulsion Laboratory.

A grant of $1,000 in 1937 facilitated the formation by Caltech of the GALCIT Rocket Research Project in that year.

Drs. William H. Pickering (left) and Louis G. Dunn are shown in 1954 as Pickering assumed the leadership of the laboratory from outgoing Director Dunn.

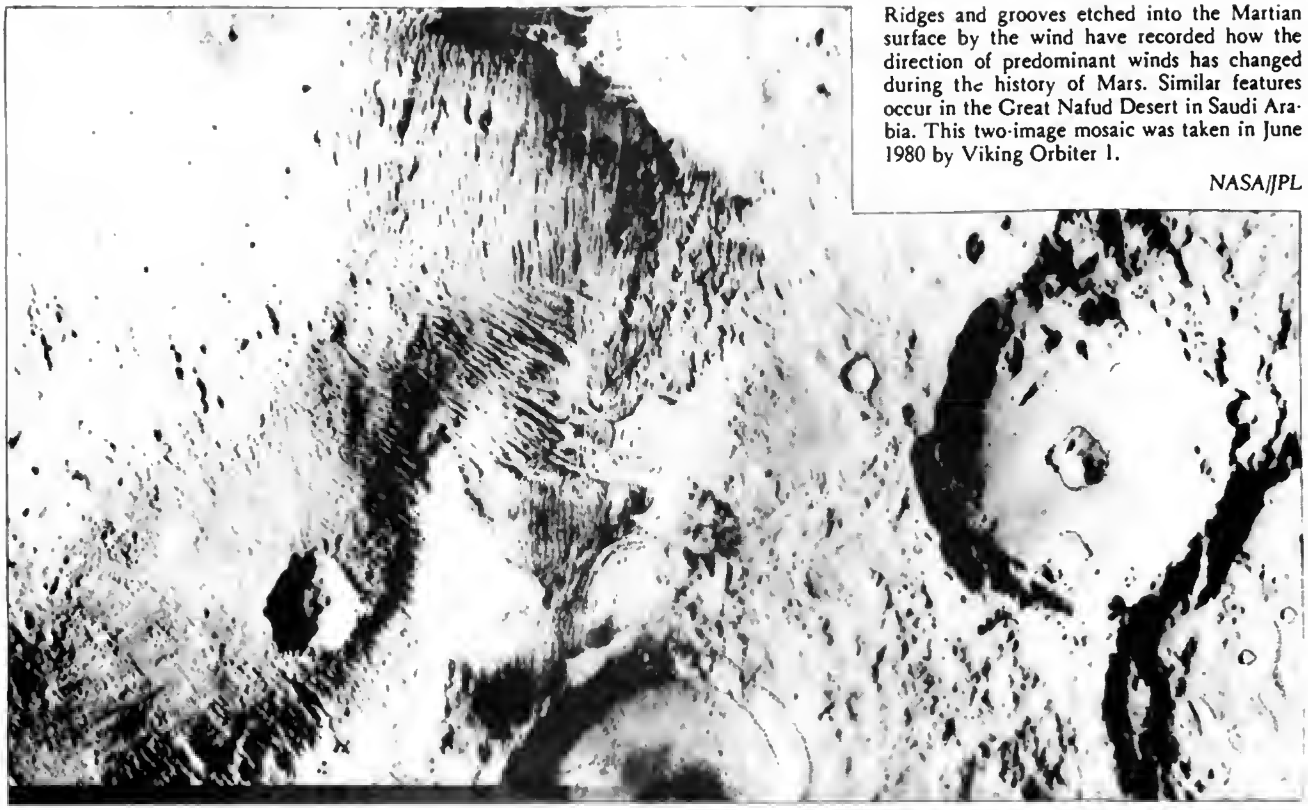
JPL Archives

Construction of temporary facilities in the Arroyo Seco began in August 1940 as Caltech started work on a US Army Air Corps contract for the design and development of rocket motors for aircraft use. It was not anticipated that the project would outlast the war in Europe. However, in 1944 the Army awarded Caltech a contract related to long-range missile development, and the original GALCIT project was assured continuance as a reorganization created the Jet Propulsion Laboratory on 1 November 1944. The word "rocket" was somewhat suspect at this time, perhaps with an aura of science fiction about it, so that the name "Rocket Propulsion Laboratory" was rejected in favour of the more acceptable "Jet Propulsion Laboratory". Hence, the present author is not writing under the heading "Space at RPL" (however, the name is not just a footnote to history since the US Air Force now maintains the "Rocket Propulsion Laboratory" at Edwards Air Force Base in California).

The first director of the Laboratory was Dr. Frank J. Malina, who organised the original graduate student research in the Arroyo Seco, and he was succeeded in 1946 by Dr. Louis G. Dunn.

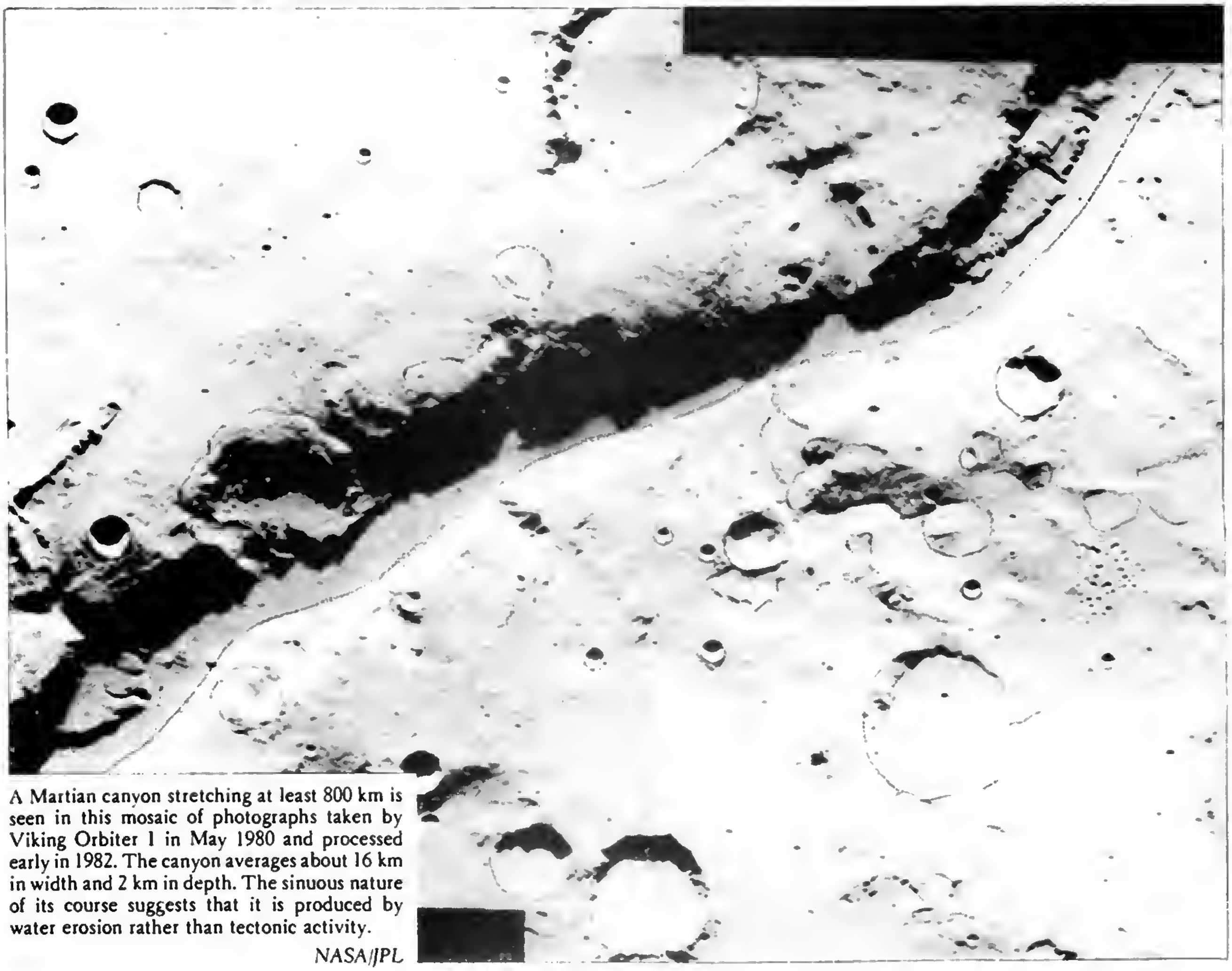
During the 1940's and 1950's JPL engaged in several rocket and missile programmes, including the WAC Corporal sounding rocket which was flown as an upper stage on the V-2 rocket, launched from White Sands Proving Ground in New Mexico.

Dr. William H. Pickering became the Laboratory's third director in 1954 and during that period JPL began to work with US Army Ordnance and the Office of Naval Research on plans to build and launch an artificial satellite. This proposal, appropriately named "Orbiter," was submitted to the Department of Defense in 1955. Later, in 1957, when problems arose in the Vanguard satellite programme, and under the pressure of the Soviet's success with Sputniks 1 and 2, the Army Ballistic



Ridges and grooves etched into the Martian surface by the wind have recorded how the direction of predominant winds has changed during the history of Mars. Similar features occur in the Great Nafud Desert in Saudi Arabia. This two-image mosaic was taken in June 1980 by Viking Orbiter 1.

NASA/JPL



A Martian canyon stretching at least 800 km is seen in this mosaic of photographs taken by Viking Orbiter 1 in May 1980 and processed early in 1982. The canyon averages about 16 km in width and 2 km in depth. The sinuous nature of its course suggests that it is produced by water erosion rather than tectonic activity.

NASA/JPL

Missile Agency (ABMA) and JPL were authorised to assemble and launch an Earth satellite. The first American satellite, Explorer I, was put into orbit on 31 January 1958, less than 90 days after authorisation to proceed was received.

As the civilian space programme gained momentum with the creation of NASA in October 1958, from the 43-year-old National Advisory Committee on Aeronautics (NACA), the new agency needed to acquire capabilities rapidly. The team that successfully launched Explorer I was sought, and on the last day of 1958 the Army ceded JPL to NASA. It was not until later that NASA was able to obtain ABMA and the von Braun team from the Army.

The 1960's and 1970's saw an enormous increase in our knowledge of the Moon and the six inner planets, with Uranus and Neptune also brought within striking distance by the ongoing Voyager 2 spacecraft.

The wheel has turned again with the decline, but happily not extinction, of the lunar and planetary programmes, and the US Army is once more becoming a significant JPL customer. The Air Force, the Navy and civilian energy research also contribute to JPL's current position as a multiple-based technological centre.

The Jet Propulsion Laboratory, as it was to be named, is seen in embryonic form in this 1941 photograph.

JPL Archives

HIGH-ENERGY ASTRONOMY

Two JPL parabolic mirrors located at Edwards Air Force Base, the Californian desert landing site for the first two Shuttle flights, have been used for observations of the star Cygnus X-3. This X-ray source is also the brightest gamma-ray source in the sky and was observed at energies exceeding 10^{11} electron volts, ranking among the highest energy astronomical observations which have been made to date.

Cygnus X-3 is a suspected pulsar and may emit pulses at a rate of about 100 per second, exceeding the fastest known pulsar, the Crab Nebula, by more than a factor of three. Using the JPL mirrors it may be possible to confirm this pulsation with further observations to be done this year.

The mirrors themselves are sized at 11 m each, with focal lengths of 6 m, and their pointing is computer controlled. They were originally constructed for the purpose of solar-energy research in the role of a high energy observatory.

PLANETARY IMAGE FACILITY

The Regional Planetary Image Facility located at JPL is a joint effort between the Laboratory and NASA in order to provide a reference library of planetary and satellite images. The emphasis is, of course, upon images returned by space probes, but Earth-based photography and relevant topographic and geologic materials are also available.

An extensive list of missions comprises the source for the collection including Rangers 7-9; Surveyors 1, 3, 5-7; Lunar Orbiters 1-5; Apollos 8, 10-17; Mariners 4, 6, 7, 9, 10; Vikings 1, 2 and Voyagers 1, 2.

The Facility, which opened in 1979, contains approximately 225,000 images accessible in photographic files and also on a versatile, computerised filing system using a video disc. Approximately 20 parameters, including planetary latitude and longitude, spacecraft range-to-planet, and lighting angle can be specified by the user of the video disc system. The programme responds to this input with a listing of all images which satisfy these criteria. The images themselves can then be displayed on a TV screen in black and white, with plans to extend the capability to a colour display of those images which were originally produced in colour.

The video disc itself is a silvery plate that resembles an ordinary gramophone record in shape. It was produced by first photographing the original prints one-by-one onto 35 mm film, transferring these to 1 in. video tape and then, finally, loading the contents of the tape onto the video disc.

Head Librarian Leslie Pieri demonstrated the remarkable properties of the disc by stepping through a sequence of Viking Orbiter images at the rate of five frames per second. As I watched the TV screen I partially enjoyed the perspective of the Orbiter since the images are stored sequentially, by consecutive orbit.

There are several other Regional Image Facilities located in the US which store NASA imaging products and also active centres in Rome and London, the latter being located at the University of London Observatory.

The Facility has no photographs available for distribution, but qualified individuals may gain access to its reference room by first applying at the JPL Visitor Center. Individuals who are not US citizens should write to the Facility several weeks in advance of their arrival in order that the necessary clearances can be obtained. The address is: Planetary Image Facility, Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, California 91109.

The director of the Facility is Dr R. S. Saunders of JPL's Planetology and Oceanography section and the Operations Manager is M. D. Martin.

VIKING MISSION CONTINUES

In the summer of 1976 the planet Mars was visited by a small fleet of four spacecraft: two orbiters and two landers. Today the orbiters are silent but the Viking 1 lander continues to return data from its location in Chryse Planitia, the Plains of Gold. It is scheduled to return imaging, meteorology, radio science and engineering data up to 1994.

More than 4,500 pictures have been returned from the landers and over 50,000 were received from the two orbiters. The latter pair mapped about 97% of the Martian surface at a resolution of 300 m, while 2% of the surface was resolved at the 25 m level. Although much valuable material was obtained by the imaging sequences taken from the landers, most of it was of a static nature; very few changes occur on the Martian surface. Only two small surface slides were noted in four years of the extended mission (the follow-on to the initial mission segment), in addition to seasonal coloration changes due to the transport of material, and the phenomenon of winter frost.

MLR: A SHUTTLE EXPERIMENT

THE MONODISPERSE LATEX REACTOR

Introduction

One of the less spectacular experiments carried out by the Space Shuttle *Columbia* on its third and fourth orbital test missions was the Monodisperse Latex Reactor. The somewhat obscure name tends to hide its purpose although the fact that NASA has allocated space aboard Shuttle missions 3 to 6 does give an indication of its value.

Basically, the MLR is an experiment designed to determine if the low gravity conditions of orbital flight will allow the production of groups of small spheres with exactly the same diameters (i.e. monodisperse). A latex is a suspension of these tiny spheres (typically of micron size, or 0.00004 in.) in a liquid such as water.

These suspensions are useful for applications in medicine and industry. For example, in measuring the size of pores in the wall of the intestine in cancer research; measuring the size of pores in the human eye in glaucoma research; and as a carrier of drugs and radioactive isotopes for treatment of cancerous tumours.

The theory is that large monodisperse latex particles can be prepared by starting with a monodisperse latex of relatively small-size particles produced in the laboratory and then using this suspension as a "seed" to grow the large-size particles. On Earth, these beads can be produced only up to about three microns and still be monodisperse. The MLR experiment will help determine if much larger (up to 20 microns) monodisperse beads can be produced economically in space.

BIS TEAM MEMBER

One of the investigators for the MLR is BIS Fellow Dale Kornfield. He says that, "This has been an extremely interesting time for me in that, as the only NASA member of the team, I have the responsibility for directing and/or performing most of the hardware testing, disassembly, refurbishment, latex loading, installation in the spacecraft at the Cape and removal at the landing site. I spent 2½ months at the Cape setting up before STS-3 and operating my chemical laboratory there to prepare the flight chemicals for loading just before launch. Standing there on the swing arm and watching the spacecraft shining a brilliant white in the glare of the great spotlights has got to be the most moving experience of my life. Just looking at that majestic vehicle and realizing that I was standing at the gateway to the stars, actually brought tears to my eyes."

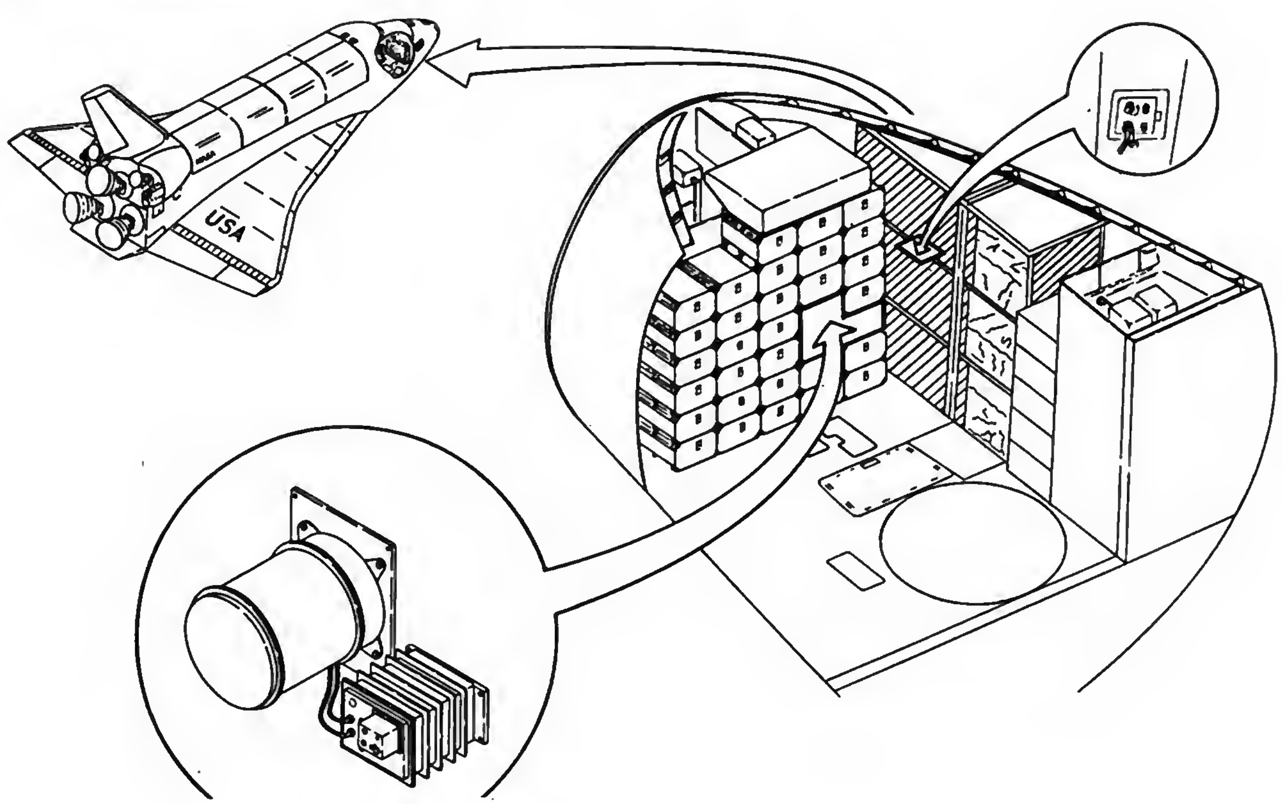
"I then flew out to White Sands for the landing, just in time to get caught in the sandstorm! Before STS-4 I spent several days in Houston teaching astronauts Mattingly and Hartsfield how to operate the MLR."

Producing the Spheres

During the growth phase the latex spheres are required to be kept in a state of suspension, generally achieved through stirring, to avoid "creaming" (floating) at the beginning and "settling" (sinking) near the end of the process. For very small

Astronaut Jack Lousma (STS-3) and Dale Kornfeld inside *Columbia* during the flight crew briefing on MLR operation. Dale was responsible for the hardware, while Drs. Vanderhoff, Micale and El-Aasser of Lehigh University performed most of the latex recipe development. STS-4 results proved to be a disappointment: the unit failed to respond properly because of an electrical fault when the crew switched it on. Later examination, however, showed that some useful material had been produced and some of the processing could be completed on the ground.

NASA



particles up to 0.5 micron (0.00002 in.) in diameter, the stirring is not necessary. However, for particles of moderate sizes gentle mechanical agitation is required.

Only when larger spheres are produced do the effects of gravity become noticeable. The suspension has to be stirred more vigorously to prevent creaming and settling and this can lead to clumping of the large spheres and the additional growth of small spheres. The result is a mixture of various sizes.

The Shuttle experiment is intended to grow latexes of increasingly larger diameter spheres, using the suspension produced from the previous mission as the starting point. The aim is to produce equipment that can generate large monodisperse spheres on a routine basis.

The flight equipment consists of an Experiment Apparatus Container (EAC) and a Support Electronics Package (SEP.) The EAC (mass 42.3 kg, size 0.416 m diameter by 0.495 m high) contains four separate, independently operated chemical reactors. These reactors are cylinders, wrapped with heating tape, containing stirrers for agitation and pistons for measuring volume change during reaction.

Each of the reactors produce latex from 100 cc of the chemical recipe loaded in each. The SEP (mass 13.6 kg, size 0.346×0.265× 0.300 m) contains a preprogrammed microprocessor to control the experiment operation after being manually turned on by the crew. The SEP also contains a recorder which stored all data produced during operation of the experiment.

The two units are attached to the Orbiter wall using adapter plates. Heat produced by the chemical reaction within the MLR reactors is dissipated passively through the normal air flow in the mid-deck during the 14 hours of operation. Thus, MLR demands on the Shuttle are simple and impose no constraints on the major mission activities.

The four independent reactors inside the EAC are loaded with appropriate ingredients at the launch site laboratory. When ready for flight, the MLR is transported to the launch pad and installed in the Shuttle about 48 hours before launch. The experiment is switched on by the crew at any time during a low-gravity period of the mission, running under the preprogrammed microprocessor control for 14 hours, and then turning itself off.

The MLR is removed from the Shuttle at the landing site as soon as possible after landing and returned to the privileged investigator for sample and data analysis. After a clean-up and refurbishment of the flight equipment and loading with a new chemical recipe, the MLR is ready for another flight.

Results from STS-3 satisfied the experimenters' expectations. They loaded the four reactors with spheres grown to 2.5 microns in the laboratory and finished the mission with 4.5 micron diameter spheres – larger than Earth-produced latexes. Some of these were then used for flight aboard STS-4 and by the end of STS-6 they hope to have reached the 10-20 micron range.

SPACE COMMUNICATIONS

INMARSAT SERVICES

Inmarsat, the International Maritime Satellite Organisation, has decided to extend its leasing of two Marisat satellites from Comsat over the Atlantic and Indian oceans to continue its shipping communications services. A third Marisat, over the Pacific, is leased to Inmarsat until January 1984.

The extended leases will act as safeguards against any problems with the Marecs 2 or the three Intelsat 5 satellites.

The 11th meeting of the Inmarsat Council, held in Norway in July, also approved the use of its satellite system for disaster relief operations on land.

Inmarsat will also conduct technical and economic studies of emergency position indicating radio beacon (EPIRB) capabilities, as well as how low-orbiting satellites for such services could be integrated with the Inmarsat system.

Inmarsat's satellite system could also be used to provide improved global communications services to aircraft. Possible applications include an air-to-ground data link for air traffic control across the north Atlantic and other areas; an air-to-ground link for transmission of flight data; air-to-ground transmission of weather data; airline communications for operational purposes; and a telex message service for passengers.

NEW TORUS ANTENNA

The first of COMSAT's new torus antennae has been installed at a site in Alaska. Communications satellite ground stations usually carry parabolic dishes which connect with only one satellite, but the new design allows the "accessing" of ten or more satellites at the same time by employing polarization and frequency re-use techniques. The design also allows the antenna to receive from satellites positioned as little as three degrees apart in the geostationary ring. Normally, satellites have to be separated (thus limiting the number of slots available) to avoid interference between their transmissions.

Courtesy of COMSAT

Other advantages are its simple mechanical design, its ability to work simultaneously with 4/6 and 12/14 GHz satellites and the ease of switching from one satellite to another.

This first commercial torus feeds Anchorage's Cable TV and Microwave Distribution Systems. The 10 m antenna is presently receiving programming from three satellites, with a capability of up to four more. About the size of a tennis court, it has no moving parts and occupies only a small fraction of the space that would be needed for several parabolic dishes.

SATELLITE AGREEMENT

NASA and Telesat Canada, the operator of the Canadian domestic telecommunications satellite system, signed Launch Services Agreements in June for the launching of Telesat's Anik satellites.

Under these agreements, NASA will launch five telecommunications satellite payloads, four on the Space Shuttle and one on a Delta at a cost of about $75 million. The satellites themselves will be worth about $130 million.

Telesat's third and fourth generation Anik C and D satellites will be the backbone of Canada's satellite communications system until the 1990's. They will carry new pay TV and other broadcasting services, as well as point-to-point voice, video and data links, private business networks and a host of other specialised telecommunications services.

The first of the D series was launched in August from the Kennedy Space Center. The next Telesat launch, an Anik C, will be one of two communications satellites launched by the Space Shuttle on its fifth flight, its first commercial mission.

COLOMBIA SHUTTLE AGREEMENT

Colombia became on 31 March the first Latin American country to sign an agreement both for a satellite launch and for a launch on the Space Shuttle.

A Memorandum of Understanding covering launch services for Colombia's domestic satellite communications programme (Satcol) was signed jointly in Bogota by Colombian Minister of Communications Dr. Antonio Abello Roca and Empresa de Telecommunicaciones (TELECOM) President Dr. Guillermo Sagra Serrano, representing Colombia, and the US Ambassador to Colombia Thomas Boyatt.

The accord provides the basis under which Colombia will enter into negotiations for a launch contract with NASA for launch services on the Space Shuttle.

The two Satcol satellites are scheduled to be launched from the Kennedy Space Center in June 1985 and August 1986, with a strong possibility that the second launch will be moved up to late 1985.

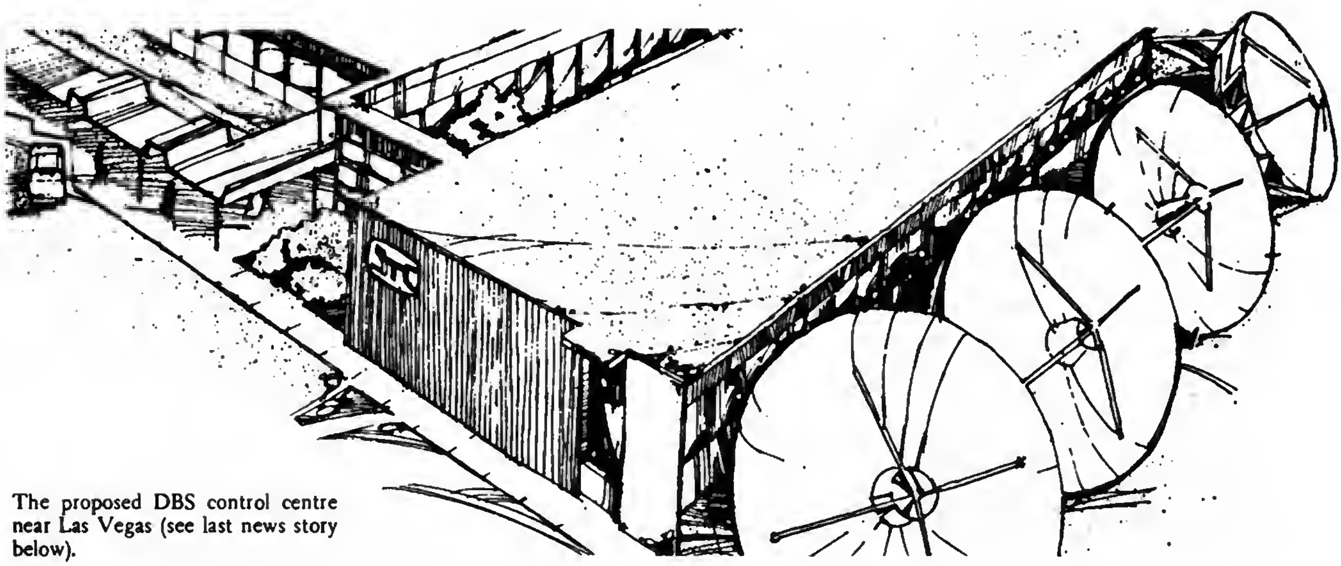
Among other nations and international organizations who have signed similar agreements to use the Space Shuttle are: Canada, Federal Republic of Germany, India, Indonesia, Italy, the Arab Satellite Communications Organization and Intelsat. In addition, Brazil and Japan have formally reserved Space Shuttle launches.

NEW GALAXY SATELLITES

Instead of building communications satellites only for other people, Hughes will now build several craft, known as Galaxy, for its own operation. Hughes Communications will sell (not just lease) transponders, each capable of carrying a TV channel, on Galaxy 1 to cable TV operators in the US.

The first Galaxy, built by the Space and Communications Group of Hughes and based on their successful HS 376 design, will be launched by Delta 3920 in May 1983 and stationed at 135 W longitude over the equator. Galaxy 2 is planned for September 1983 and will also provide a variety of other services, such as teleconferencing, and data and voice transmission. A third 24-transponder satellite is also planned.

The lower drum of solar cells seen in this illustration extends after launch, with the antenna flipping up into its operational position. The beams cover the main United States, Alaska and Hawaii.



The proposed DBS control centre near Las Vegas (see last news story below).

SPREADING THE WORD

Australian TV viewers will soon be offered the delights of American television. Subject to Federal Communications Commission approval. 24-hour transmissions via a Pacific Intelsat satellite will be beamed to an Earth station near Sydney for distribution by Channel 7. The owners? Seven Network Australia, intend to use a variety of programmes, including NBC News specials and Cable News Network.

SHUTTLE TRACKING

While astronauts aboard the Space Shuttle attend to their duties, more than 2,500 people track their movements from Earth via NASA's communications network, NASCOM.

The control centre of the network is at the Goddard Space Flight Center near Washington, D.C. Goddard receive all messages and data (except during launch and recovery) transmitted from the Shuttle and then relays them to all of the NASA and DoD facilities involved.

The control centre is linked with 15 ground stations around the world equipped with antennae and radar systems. The United States has support agreements with the Governments of Australia, Botswana, Bermuda, Chile, Senegal, Spain and the UK for tracking and collecting data.

DBS CONTROL CENTRE

The Satellite Television Corporation (STC) a subsidiary of COMSAT Corporation, intends to build a Broadcast Center near Las Vegas to operate with its planned satellite-to-home pay television service using direct broadcast satellites (DBS). It recently signed an option on 36 acres of land northwest of the city.

The Broadcast Center will be a major hub of activity for the DBS system. It will contain the equipment needed to control the satellites and to transmit programming to them. Programme scheduling, editing, reproduction, technical quality control and broadcasting will be controlled from the centre.

STC asked the Federal Communications Commission (FCC) in December 1980 for authority to construct DBS satellites. The construction programme is expected to take more than three years, resulting in the start of DBS service in late 1985 or early 1986.

As reported in a recent "Space Communications" (*Spaceflight*, July–August 1982, p. 301), Arthur C. Clarke has received the eighth Marconi Fellowship for his contributions to communications science and technology. The award ceremony took place in the Hague on 11 June with HRH Prince Claus of the Netherlands making the presentation of what Arthur calls "a truly beautiful trophy". A large part of the $35,000 award will be used in helping to establish the Developing World Communications Centre at the University of Moratuwa in Sri Lanka.

Arthur also made a trip to the Soviet Union and met, among other cosmonauts, Alexei Leonov who, we are assured, was delighted to be presented with some BIS ties.

1983 SUBSCRIPTION FEES

Direct Debit Scheme

As from 1 January 1983, our old Bankers Order System is being superseded by the Direct Debit Scheme. Introducing the new scheme smoothly makes it essential that all members who formerly paid by Bankers Order complete and submit their Direct Debit slip at once. Those members who have not already done so are *urged to deal with this without delay*. Duplicate Direct Debit slips are available from the Executive Secretary on request.

Amounts payable for the calendar year January-December 1983 are as follows:

RATES

Members	Sterling	US Dollars
Under the age of 18 years	£16.00	$35.00
Between 18 and 20	£18.00	$40.00
21 years of age and over	£21.00	$45.00
Associate Fellows	£23.00	$50.00
Fellows	£23.00	$50.00

Age Allowance

A deduction of £2.00 ($5.00) is allowed to members of every grade who are over the age of 65 years on 1 January 1983.

JBIS and *Space Education*

The additional subscription payable for *JBIS*, where required in addition to *Spaceflight*, is £20.00 ($44.00). For *Space Education*, it is £4.00 ($9.00).

Methods of Payment

Europe

(a) Payment should normally be made in sterling with a cheque which shows a UK address, either of the paying Bank or its Agent, where it can be presented for payment.

(b) Cheques drawn in sterling on banks in Europe (including Euro-cheques) must include £2.00 to defray bank charges and collection costs.

(c) Banks which remit directly to the Society must be instructed by members to see that the sum is transmitted *free of deductions*. (Banks frequently impose charges "in transit," so the amount actually received by the Society is insufficient to pay for the subscription thus causing much additional correspondence and trouble both to the members concerned and to the Society).

(d) Remittances from Europe can be made by GIRO: this is the easiest and cheapest method of transferring funds. Our GIRO account number is 53 330 4008.

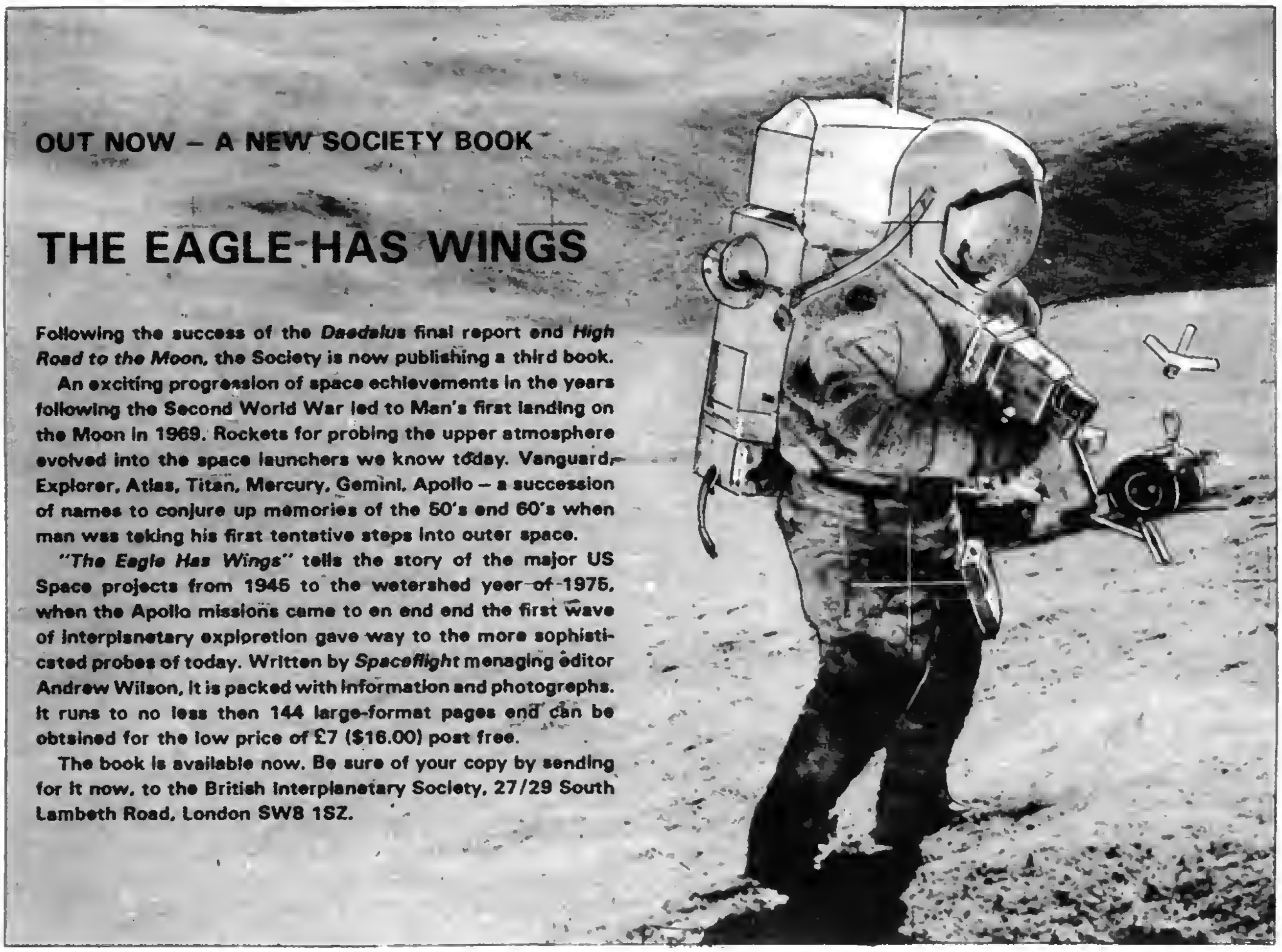
USA and Canada

(a) Payments by US dollar cheques will be accepted if drawn on a Bank which gives an address in the United States or in the UK. US dollar cheques drawn elsewhere need to be increased by $8.00 to cover bank and collection charges.

(b) US dollar notes are accepted. Other currencies may also be accepted with prior agreement by the Society. Their value must be sufficient to include conversion costs into sterling.

(c) US or Canadian money orders can only be accepted *if expressed in Sterling. Internal* money orders from these countries i.e. those expressed payable in dollars will be returned as they are not cashable in the UK.

(d) Most Canadian banks have UK branches or agents: remittances may easily be made in sterling drawn on those agents. If payment is made in Canadian dollars the current exchange rate may be used, plus the addition of 8 Canadian dollars to cover exchange and collection charges.



SPACE STATION GOAL

Deputy NASA Administrator Dr. Hans Mark, speaking in Los Angeles, recently confirmed that the building of a permanent space station is the next major NASA goal, writes Gerald Borrowman:

"We have only two priorities. The first is to make *Columbia* and her sister ships a truly effective system. The second is to establish in the next five years the programme that will put us into space on a permanent basis."

"We are looking now at an initiative to establish a space station of some kind and we want to get the initial work going on this in the Fiscal Year 1984 budget. We have a number of study groups going on this. At NASA Headquarters we have people working on it as well as various other groups."

But, he said, "We have not yet persuaded the President that this is indeed a proper goal for this nation to pursue."

Dr. Mark explained that a permanent space presence was necessary for national security and, besides, going into space is profitable. He noted that there are 30 US private companies making money from developing and flying communications satellites.

NASA announced on 20 May that it was establishing a Space Station Task Force under the direction of John Hodge (originally from London) and Bob Freitag (a long-standing Fellow of the BIS).

LAUNCHER STUDIES

Under contract with the NASA Marshall Space Flight Center in Huntsville, Alabama, Boeing Aerospace engineers are performing preliminary design work on a proposed Shuttle-Derived Cargo Launch Vehicle (see April's *Spaceflight*, p. 155). This unmanned vehicle would serve as an extension of the Space Shuttle, placing payloads too large for the Shuttle into orbit. It would also allow the Shuttle to be used more frequently for critical missions requiring manned operations and longer time in orbit. Boeing is trying to minimise development risk, cost and time by using proven Space Shuttle flight hardware and technology.

The study's objective is to provide NASA with the technical and economic data necessary to evaluate such a vehicle. Engineers will further define costs, payload manifesting, various missions and how cargo could be divided between the Shuttle and the derivative vehicle.

The basic design concept consists of the Space Shuttle main engine and a shortened Shuttle External Tank which, together, act as the core stage. Two shortened Space Shuttle Solid Rocket Boosters would be mounted on each side of this stage. The large payload and a kick stage would be placed above the core within a canister shroud.

During ascent, the Solid Rocket Boosters would be separated from the External Tank and payload at about 177,000 ft (54 km). The boosters would be recovered by the same means as the Shuttle. After reaching main engine cutoff at about 160 nautical miles (300 km), the core stage would be jettisoned into the ocean. The kick stage would then provide the final insertion into low Earth orbit at about 150 nautical miles (280 km). Recovery of the Shuttle engine and the kick stage by a Shuttle orbiter will be considered. Using the Shuttle launch facilities, the vehicle would be able to place payloads into orbit weighing up to 87,000 lb (39,500 kg).

For payloads with high-orbit destinations, an upper stage vehicle would replace the kick stage. After main engine cutoff, the upper stage would take the payload to a higher orbit such as geosynchronous orbit, some 22,300 miles (36,000 km) above the Earth.

On all missions, the proposed Shuttle-Derived Cargo Launch Vehicle would be guided and controlled during ascent by the avionics package of the upper or kick stage.

ARIANE SCHEDULE

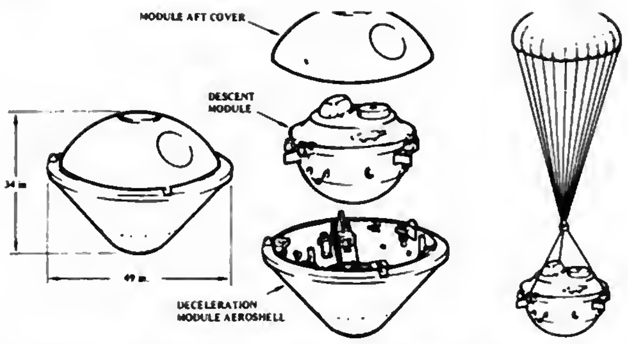
The delay from April to September in launching the Marecs and Sirio satellites by Ariane L5 has affected the rest of the launch schedule. In the October 1981 *Spaceflight* (p. 264) we published a tentative manifest; since then there has been some movement of payloads between vehicles:

L6	Nov 82	Exosat
L7	Jan 83	ECS 1 & Oscar 9B
L8	Mar 83	Intelsat 5 F7
L9	May 83	Intelsat 5 F8
L10	Jly 83	ECS 2 or Telecom 1A or Intelsat 5 F9
L11	Oct 83	Intelsat 5 F9 or ECS 2 & Telecom 1A or 1B
L12	Nov 83	Westar 6 & Telecom 1A or 1B or ECS 2

ECS is the European communications satellite, while Oscar is an amateur craft designed to replace the satellite lost in the Ariane L02 launch failure. The L10 payload will depend on which of those listed is ready first, and L11 could use either an Ariane 1 (for Intelsat 5 F9) or Ariane II (for ECS 2 and Telecom). L12 will use the more powerful II version to launch two communications satellites. *(The L5 failure may now affect the schedules further—Ed)*

GALILEO JUPITER TEST

A high-altitude balloon-drop test of the Galileo Atmosphere Probe spacecraft, which will make the first descent into the atmosphere of Jupiter, was made during June at the White



Galileo has undergone yet another change of launcher. Instead of being sent towards Jupiter in 1985 by an Inertial Upper Stage it now again looks as if the Centaur stage will be modified to do the job. Launch date would slip to 1986 but arrival would be in 1988 because of the more powerful upper stage

Sands Missile Range in New Mexico.

The Galileo probe will be launched to Jupiter in 1986. It will reach the planet in 1988, and fly 100 miles (160 km) down into the atmosphere of the giant planet, penetrating below the swirling clouds to a pressure level 20 times higher than that on the Earth's surface. This will be the first direct sampling of the atmosphere of any outer planet. Scientists are extremely curious about the composition of Jupiter's atmosphere, for what it tells about the Solar System and about giant Jupiter itself.

At the drop altitude, the spacecraft (consisting of the Galileo Deceleration Module and the Descent Module) separated from the balloon. As it dropped, it experienced speeds and deceleration pressures virtually identical to those it is expected to encounter in Jupiter's atmosphere. The purpose of the test was to demonstrate the parachute deployment sequence, and separation of the Deceleration Module from the Descent Module. A small pilot 'chute separated the aft cover from the Deceleration Module, and extracted the large main parachute. The rest of the Deceleration Module (heat shield and aeroshell structure) then separated from the Descent Module, which completed the flight, descending on the parachute.

The balloon drop was made from about 19 mi (30 km) above the Earth, following launch from Roswell in New Mexico.

URANIAN DISCOVERIES

Three University of Hawaii astronomers have succeeded in measuring the sizes of four of the five known moons of Uranus, almost 3,000 million km away.

NASA's Voyager 2 spacecraft is now heading towards the planet following its successful flyby of Saturn in August 1981. The new information will be important for planning the scientific studies to be made when Voyager arrives in 1986.

Measurements of their infrared (heat) radiation were made with the NASA Infrared Telescope Facility (IRTF) on Mauna Kea in Hawaii. This telescope, the most sensitive instrument in the world for observing faint infrared sources, was built by NASA in part to provide support for spacecraft exploring the planets.

Dr. David Morrison, one of the University of Hawaii team and a member of the Voyager project, noted that these measurements represent exactly the sort of astronomical support for spacecraft that NASA had in mind when the facility was built.

This new information reveals for the first time that the moons are large bodies, with diameters ranging up to 1,690 km (about 1,100 mi) for Oberon, the largest. Although smaller than the Earth's Moon they are as large as the moons of Saturn, except for Titan, the only planetary satellite with a major atmosphere.

It also appears that they are darker than the bright icy Saturnian moons investigated by Voyager. This was a surprise to many scientists, who had suspected that the Uranian moons might also be bright because of water ice which was discovered from astronomical observations carried out at Mauna Kea several years ago.

The brightness and colours of the surfaces closely resemble those of one of the smaller moons of Saturn, Hyperion.

In addition to the Uranian measurements, the researchers found that Pluto and Triton, the largest satellite of Neptune, are both too small and cold for their heat radiation to be detected. From the weakness of these sources, they calculate that Triton must be smaller than our Moon.

Dr. Dale Cruikshank, who has been studying these two bodies for many years and was the discoverer of methane ice on the surfaces of both objects, comments that the new results effectively eliminate the possibility that Triton is large. He says that both Triton and Pluto appear to be cold, icy objects of sub-lunar size. "Based on our current knowledge, they may be physically very similar to each other." There has been speculation in the past that Pluto might be an escaped moon of Neptune.

ARIANE CONTRACT

A contract has been awarded to Marconi Space and Defence Systems to supply flight programs for the first Ariane production vehicles. This follows the successful completion of the Ariane development phase when the vehicles were controlled from the moment of lift-off by programs developed and produced by Marconi. The Marconi Ariane software team has recently completed a program development contract for an improved Ariane and is likely to be involved in similar development work for future versions of the vehicle during the next decade.

After launch, Ariane is autonomous except for range safety considerations. The flight program guides the launcher along an optimum trajectory into the required orbit. This involves several main processes:

1. Inertial navigation, using inputs from the inertial platform, to calculate vehicle position and velocity.
2. Guidance computation to correct the remainder of the trajectory into the required orbit, and determine the current attitude of the vehicle.
3. Sequencing control of vehicle systems throughout the flight, including stage, fairing and payload separation.

After Ariane has been injected into the correct orbit, the program controls payload orientation and spin.

The program for a particular mission is produced by combining a reference program with the appropriate flight plan and orbit data base. Testing is carried out by running the program in an Ariane on-board computer, interfaced with a scientific computer which contains a mathematical representation of the launch vehicle's performance characteristics.

KOMAROV MEMORIAL

Radio Moscow's Home Service announced on 27 May that a memorial had been unveiled in the Orenburg Steppe, 40 km from the worker's settlement of Novoorsk, in memory of Vladimir Komarov who was killed during the Soyuz 1 mission in April 1967, writes Neville Kidger. The memorial is located on the spot where the spacecraft crashed.

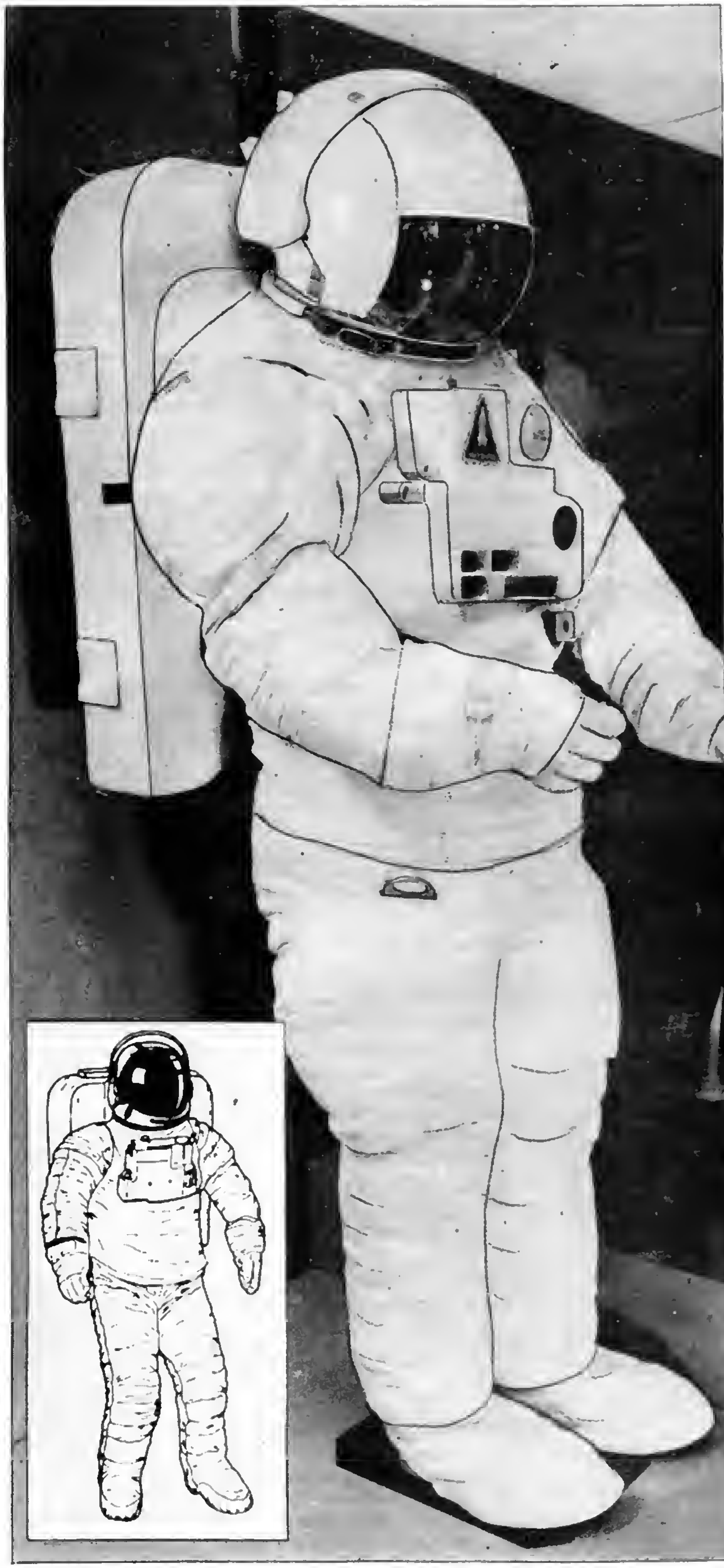
SHUTTLE SUIT DISPLAY

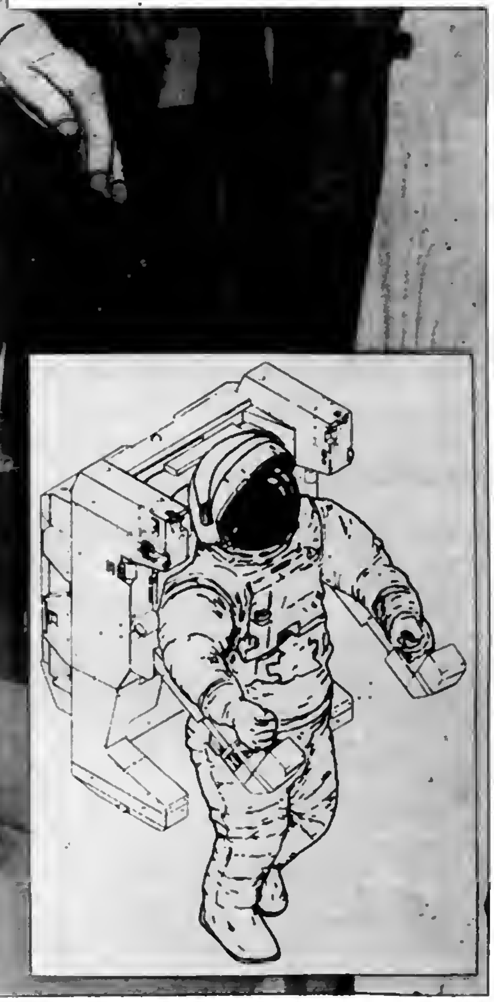
The London Science Museum recently included a replica of a Space Shuttle EVA suit among its exhibits. Similar suits will be used during the first Shuttle space walk, planned for STS 5 in November.

The two-piece outfit is the lightest, most durable and flexible space suit produced so far, available in three sizes to fit both male and female astronauts. A hard upper torso with flexible arms is mated to a single-piece lower section with "waist mobility" and integral boots.

The outer layer is a 40:40:20% (by weight) fabric of Nomex, Teflon and Kevlar fibres, respectively. Immediately below are five layers of aluminised Mylar reinforced with woven Dacron. The final layer is Nylon coated on one side with Neoprene. The pressure restraint layer of the fabric arms and legs is Dacron, while the innermost layer (bladder) is a Nylon fabric coated with polyurethane film and heat-sealed to form gas-tight seams. The rigid upper torso is made from E Fibreglass and epoxy resin. A liquid cooled undergarment removes body heat.

The December 1981 issue of *Space Education* carries a 2 pp. description of the Shuttle suit and its operation.





CANADIAN SPACELAB EXPERIMENTS

Canadian scientists have long been interested in the study of the aurora borealis and the upper atmosphere, writes Neville Kidger. The space research committee of the National Research Council has supported a national rocket and balloon programme to explore the relationship between upper atmospheric particles and the aurorae. Now, the NRC is set to further the work by sending instruments into orbit on the Spacelab 6 flight in 1987.

In the 1960's Canada developed the Alouette-ISIS series of four scientific satellites which produced a wealth of information about the ionosphere and magnetosphere. In 1980 the Canadian government approved a significant increase in the level of funding for space science and, as a result, a number of new projects were started in collaboration with NASA and the Swedish Space Corporation.

Canada is building three new major instruments to be flown on Spacelab 6. They are:

Energetic Ion Mass Spectrometer. This device will allow scientists to examine charged particles in the Earth's magnetosphere and will be far more sensitive than previous spaceborne instruments of its type. It will be used to measure the composition and energy distributions of ion species occurring naturally in the magnetosphere as well as tracer ions injected by NASA experiments.

Wide-Angle Michelson Doppler Imaging Interferometer. This advanced optical device, a joint venture with several Canadian universities, will study the vertical distribution of winds in the upper atmosphere and obtain data on small scale irregularities and temperature variations there. WAMDII will provide high resolution measurements of the doppler frequency shifts caused by winds in light emitted from atmospheric ions and molecules. Images of selected regions of the atmosphere using a newly-developed electro-optical detector array will be produced.

Waves in Space Plasmas. This device will study the effect of radio waves (in the frequency range of 0.3 to 30 MHz) on the Earth's ionosphere and magnetosphere.

The EIMS and WAMDII experiments will be mounted on a pointing device on a Spacelab Pallet in the payload bay whilst WISP will use two slender antennae extending outwards from the rear of the bay.

In addition, Canada is also to provide an ultraviolet imager for the Swedish Viking satellite (due for launch with the French SPOT satellite aboard an Ariane in 1984) which will provide up to six images per minute in two UV wavelengths of the distribution of aurorae over the northern polar cap. It will enable aurorae to be seen in the sunlit hemisphere and will yield information on the spectrum as well as spatial distribution and energy flux of auroral particles.

SOLAR OBSERVATORY STUDIES

The Space and Communications Division of British Aerospace has received a £133,000 contract from the European Space Agency to conduct a Feasibility Study of DISCO, one of five new space science projects being studied before selection as Europe's next major scientific satellite (see *Spaceflight*, June 1982, pp. 266-267). The work will take seven months.

DISCO (Dual-Spectral Irradiance and Solar Constant Orbiter) is proposed as a long-term solar observatory to monitor variations of the Sun's surface, the heliosphere and the solar wind. This will give scientists a better understanding of the internal workings of the Sun, and of its effect on Earth's climate. Some of DISCO's instruments are also intended to support the observations of the International Solar Polar Mission.

ISPM will be launched towards Jupiter in 1986 where the immensely strong gravitational pull will be used to accelerate it out of the ecliptic plane in order to observe the Sun's polar regions.

An interesting feature of DISCO is that, to provide long-term uninterrupted viewing of the Sun, it would be placed in orbit around the L1 Lagrange point, a position about 1½ million km from Earth towards the Sun, where the gravitational fields of the Earth and Sun balance.

Other space science projects presently being studied on behalf of ESA include X-80 (an X-ray observatory), ISO (a cryogenically-cooled infra-red telescope), Magellan (an ultraviolet spectrograph) and Kepler (a Mars orbiter). On completion of these industrial feasibility studies by the end of 1982, ESA, in conjunction with the European scientific company, will choose the next scientific space mission to enter development.

SHUTTLE LANDING SYSTEM

When the Space Shuttle begins its routine cargo flights, the astronauts will hand over the landing phase to microwave beams and the onboard computers. The Orbiter's computers will receive vital positional information from a Microwave Scanning Beam Landing System (MSBLS) housed in two small buildings near the runway at the Kennedy Space Center.

The beams must be precise. The microwave equipment, operated by RCA, carries a rating of "criticality 1", meaning that a malfunction could cost the astronauts their lives.

Basically, the MSBLS guides the Orbiter by transmitting a horizontal beam to provide azimuth (left and right) and distance information, and a vertical beam to tell the computers the elevation angle. With this information, the computers can pilot the craft.

For the first mission, Young and Crippen operated the landing controls as they learned the "feel" of the large, unpowered craft. In the future, however, the MSBLS and computers will routinely land the Orbiter at a predesignated site, usually Florida or California. During STS-2, the on-board MSBLS computer was programmed to guide the Orbiter to the threshold of the landing site runway before manual control was applied.

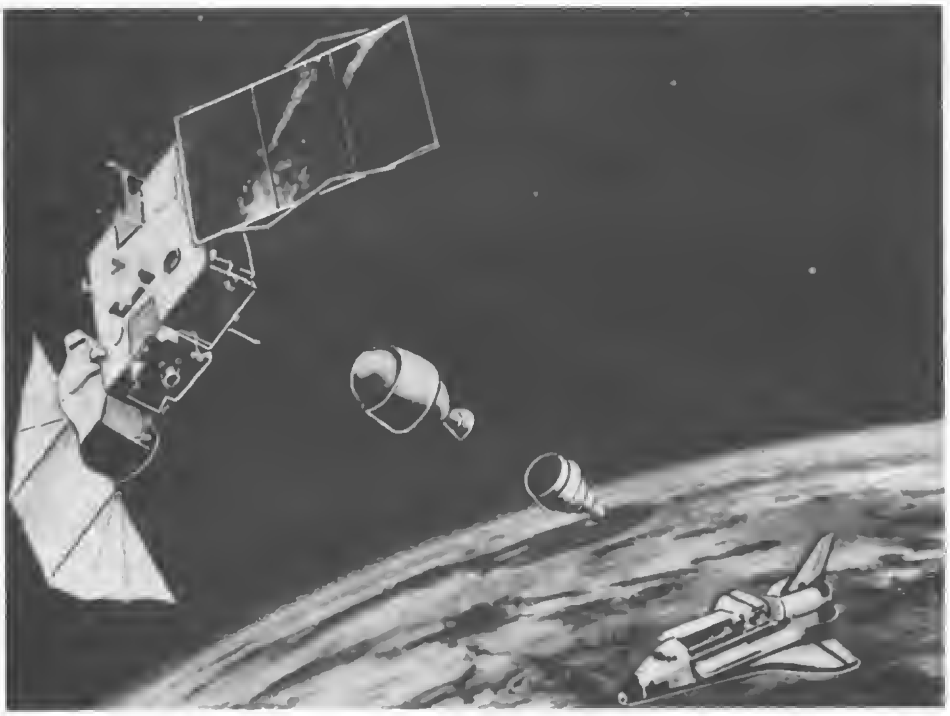
Should an emergency arise, the Orbiter could be safely landed without the help of the astronauts. In theory, the microwave system can guide the nose wheel down within the width of the paint stripe on the runway's centre.

ANTENNAE IN SPACE

Radio astronomy is likely to take a giant step over the next decade, according to physicist Dr. Samuel Morgan of NASA's Marshall Space Flight Center. Morgan is study manager for a future NASA space-based radio astronomy system known as the Very Long Baseline Interferometer. The system would link an orbiting antenna to one or more antennae on Earth to provide high resolution coverage of the radio universe.

"In years past", said Morgan, "ground-based radio telescopes have produced some spectacular results, including the discovery of pulsars, quasars and other galactic phenomena. But now we're looking to space-based systems for even better results."

A long baseline interferometer is a system of antennae, placed thousands of miles apart, that simultaneously study the same area of the sky. This linkage would provide high-resolution images of celestial sources that cannot be achieved with a single, independent radio astronomy antenna. The signals



The military STS-10 mission in November next year will take the US Air Force "Teal Ruby" satellite aloft to test an infrared mosaic device for detecting aircraft from orbit by the heat they produce. The satellite will also carry two 8 cm diameter, 4×10^{-3} N Mercury ion thrusters (visible in the picture as two small cylinders on top and on the front of the main body) to test for station-keeping purposes.

Although Teal Ruby will be in a low orbit, because of its reconnaissance mission, the exercise will help to show if the thrusters are suitable for holding geosynchronous satellites in position. If they are, then there will be a significant weight-saving over present systems. See news item below.

received by each antenna in an interferometer system are recorded and synchronised by extremely accurate atomic clocks. These signals are later combined to produce radio images. The longer the distances (baselines) between the antennae, the larger the effective telescope size. Two radio telescopes, placed a 1000 miles (1600 km) apart, in effect make a radio "dish" of the same size. "One of the longest baselines on Earth is 6,600 miles (10,600 km)," said Morgan, "with antennae in California and Australia, and that system is highly sensitive. But imagine the resolution you'd get if you were to link it with an antenna far out in space."

Morgan is a member of the Very Long Baseline Interferometer Working Group, consisting of members of universities, laboratories and NASA centres, which was chartered in 1981 by NASA's Office of Space Science and Applications to develop ideas for placing an interferometer in space. The group has proposed launching an experiment aboard the Space Shuttle in the late 1980's.

One proposal is to position a large interferometer in a 5,000 km orbit sometime in the late 1990's. "By interfacing it with sister antennae on Earth, resolution greater than a milli-arcsecond could be achieved," said Morgan. This is equivalent to being able to see a 1 cm diameter disc from about 5,000 km away.

NEW INFRARED MAP

A map of the Orion Nebula, which shows newly formed stars not visible to the naked eye, has been created using infrared data obtained from NASA's Kuiper Airborne Observatory.

The observatory is a Lockheed C-141 Starlifter aircraft, equipped with a 91.5 cm (36 in) aperture Cassegrain-type reflector telescope installed in an open cavity in the port side immediately ahead of the wing. The telescope can be moved in flight over an elevation range of 35 to 75°. It is capable of tracking celestial objects to an accuracy of less than two arc seconds by use of precision gyroscopes and an active digital tracking system.

The "invisible" stars have been under study by infrared astronomers since their discovery some 15 years ago. Total power output of this group of very young bodies is more than 100,000 times the power of our Sun, infrared observations have shown.

TEAL RUBY SCHEDULED

The USAF Space Test Program satellite Teal Ruby (P80-1) has been scheduled for the tenth Space Shuttle flight in November 1983 aboard the Orbiter *Challenger*, writes Joel Powell. The payload will be designated as DoD 83-1. Designed to test an infrared tracking array to detect ICBM warheads and aircraft from space, P80-1 will also carry Lasercom, an experimental package for evaluating low bit-rate data transmission via laser. Lasercom has been ground tested with the Air Force KC-135 airborne laser laboratory. Teal Ruby will be injected into a 72.5°, 740 km orbit.

"WEATHER REPORTER"

The Nippon Electric Company have developed a meteorological satellite data utilisation system called the Nesdus-101, or the Weather Reporter, writes Nicholas Steggall. It is capable of receiving image signals from the five geostationary satellites in the World Weather Watch (WWW) programme. The Weather Reporter consists of a compact light-weight parabolic antenna and a signal processor unit. To this can be added a video tape recorder, facsimile recorder or TV hard copy unit to provide a hard copy of the received image. The Weather Reporter also has provisions for magnification of specific portions of the image and can also provide animation of a number of simultaneous images in order to follow a weather system.

UK SPACE SYMPOSIUM

A symposium sponsored by the UK Department of Industry on the "Investment in Space, Public and Private Partnership" was held earlier this summer. The objective, as explained by the Minister of State for Industry and Information Technology, Kenneth Baker MP, was to bring together leading representatives of the investment, space manufacturing, Governmental and space user communities in order to discuss how best to exploit commercial opportunities and facilitate UK private investment in space activities.

Participants included senior representatives from many of the leading financial, industrial and Governmental organisations in the country.

The symposium, hosted by Logica Ltd., was chaired by Roy Gibson, former Director General of the European Space Agency and now a special consultant with Logica on aerospace affairs. Presentations were given by Sir Hermann Bondi (Chairman of the National Environmental Research Council). David Withers (Chief Engineer at British Telecom International), David Berriman (Chairman of Satellite Television Ltd), Andrea Caruso (Secretary General of EUTELSAT), Ray Munday (Sales Manager of British Aerospace Dynamics Group Space and Communications Division), David Stanley (Director of Aerospace Group, Logica Ltd), Professor John Houghton FRS (Deputy Director of the Rutherford Appleton Laboratory) and Bernard Myers (Corporate Finance Director of N. M. Rothschild & Sons).

The scale of future markets and the extent of the required marketing effort are both widely underestimated, it was suggested. The coming decade will show a marked swing in space programmes towards the importance of software elements, that is, activities on the ground required to interpret and apply the services offered by satellites.

Although not an infallible guide to the future, the corresponding market development in the USA over the last decade offers a useful guide to the potential in Europe. The UK can learn from the early overselling of remote sensing in America and should pay particular attention to educating potential users, to understanding their needs and to building up the national infrastructure necessary for the exploitation of European remote sensing satellites.

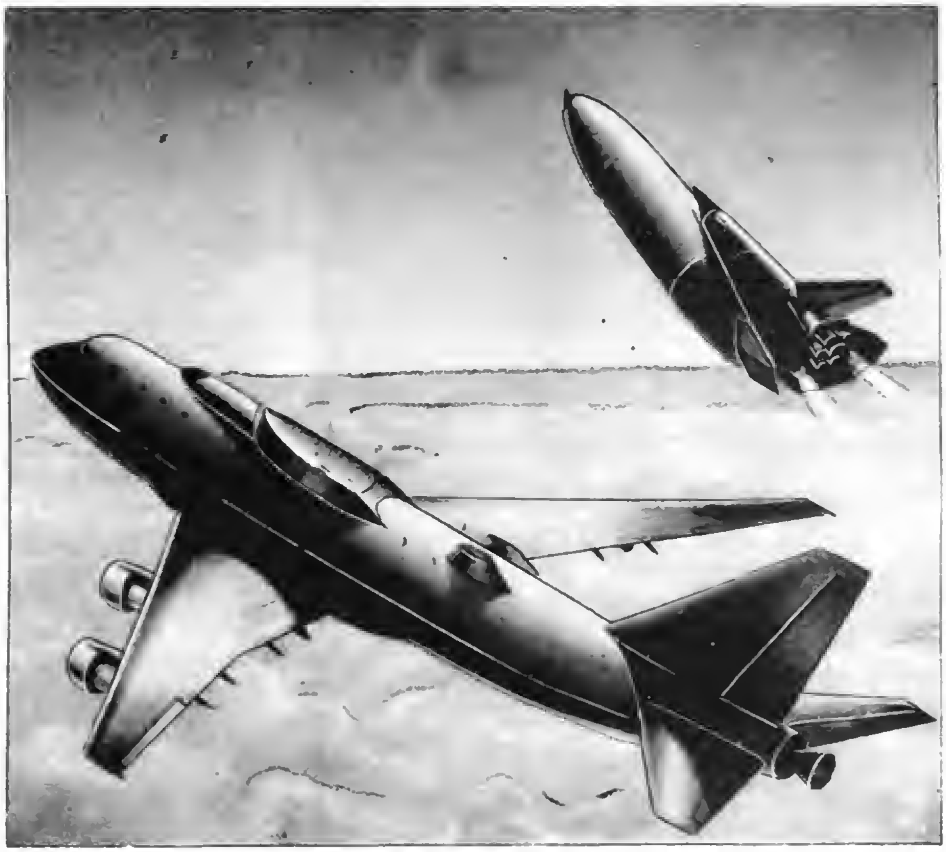
There was particular concern at the symposium that the large market for ground-segment equipment in the TV broadcasting sector should not fall to American and Japanese manufacturers. It was thought that overseas market prospects should be tied in more closely with governmental aid to the less developed countries.

The space business bears comparison with other recent advanced technology, capital intensive, high risk investments such as North Sea oil. Insurance schemes have been developed which can reduce the risk of the funding institutions to acceptable levels. Potential investors require a rigorous and detailed assessment of the risks and rewards before committing their funds.

In the short term, one of the most profitable space investments is likely to come from entertainment. Other applications such as education and business services may well be able to benefit later from the infrastructure created for the entertainment market. In the USA the distribution of broadcasting programmes by satellite has proved a base upon which telecommunications services by satellite have ridden.

National telecommunication authorities hold the key to the growth of communications satellites in Europe for the foreseeable future. The relaxation of common carrier monopolies was an important factor in the explosive growth of such satellites in North America. A similar climate should be encouraged in Europe.

There are substantial legal and administrative complications to the development of most forms of satellite services in



A reusable spacecraft launched from atop a modified 747 commercial jet is shown here just seconds after engine ignition. Two rear outboard engines ignite to control and steer the vehicle. Once the spacecraft has cleared the 747's tail, the remaining seven engines ignite to provide the main propulsion. The spacecraft climbs to low Earth orbit, releases its payload, and then returns to Earth, gliding to a halt on an airport runway. Boeing has recently finished design studies of this Air Launched Sortie Vehicle for the Air Force's Rocket Propulsion Laboratory, and has determined that such a vehicle could fly its first mission in 1988. It would have obvious applications as a search-and-destroy vehicle for Soviet satellites.

Europe, including TV broadcasting, data transmission and remote sensing. These complications can only be fully appreciated, and hopefully overcome, by realistic trials.

UNUSUAL MILITARY SATELLITE

Earlier this year, on 21 January, the US Air Force launched its 62nd Titan 3B. Its payload entered a 143 by 537 km orbit, with a period of 91.40 minutes and an inclination of 97.32°, writes Anthony Kenden. Most observers of the US military space programme quickly classed it as a routine high resolution "close look" photographic reconnaissance satellite because of its tell-tale low perigee and Sun-synchronous inclination. However, subsequent manoeuvres showed it to be an unusual mission.

The low perigees used by close look satellites mean that they experience considerable atmospheric drag, forcing them to make daily manoeuvres to counter orbital decay. A day after launch, the new satellite (1982-06A) manoeuvred, but the resulting orbit was much higher than those used by close look satellites. It was the first indication that the satellite was not all that it had originally seemed. It was to surprise observers again and again over the next four months.

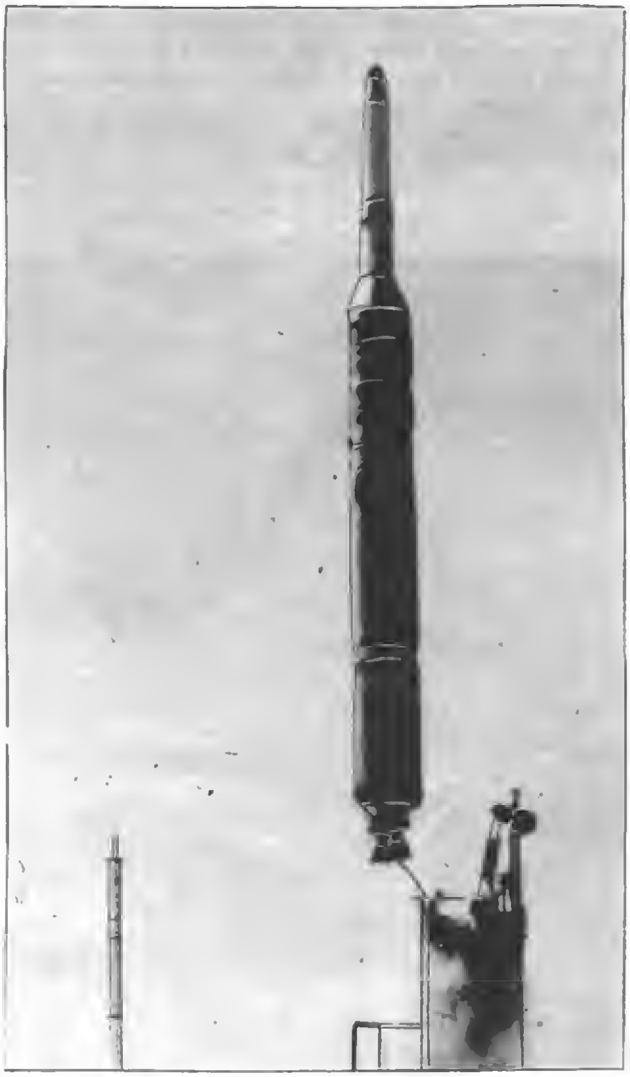
1982-06A's new orbit had a perigee of 553 km and an apogee of 645 km, with a period of 96.73 minutes. At this altitude it showed virtually no atmospheric decay. Was it simply a close look satellite in a parking orbit waiting to be called down to active service when the need arose? The answer was shown to be "no" on 29 January, when 1982-06A manoeuvred again, raising its perigee to 582 km. By 9 March it had raised its orbit a further six times, resulting in a path of 622 by 655 km, with a period of 97.55 minutes.

After a week of this, 1982-06A manoeuvred again, but this time lowering its orbit. Five days later it released three objects into their own orbits. The main satellite then continued to lower its path, until by 22 April it ranged from 601 to 613 km. Five days later a second relatively large manoeuvre was made, raising the orbit to 633 by 645 km, and after another six days a fourth object appeared.

Having manoeuvred 16 times in 96 days, 1982-06A now became inactive. For 26 days it stayed in this high orbit, decaying slightly but showing no signs of any manoeuvring. Finally, on 23 May, it fired its engine for the last time and pushed itself out of orbit. It had been in space for 122 days.

There are no obvious clues as to what 1982-06 was actually doing, either from its orbital behaviour or from reports in the press, but it is possible to make some intelligent guesses. Examining all the types of US military space activities and eliminating those for which current and future programmes have been well publicised leaves photo reconnaissance, electronic intelligence and ocean surveillance as possibilities. Of these, the most likely appears to be to test systems for the new advanced KH-11 photo reconnaissance satellite, due to enter service in 1984.

A paper by Anthony Kenden on this unusual satellite appears in the October 1982 "Space Chronicle" issue of JBIS – Ed.



Launch of a Titan 3B.

SOLAR SATELLITE RESULTS

An 18-month decrease in the Sun's energy output, recently detected by the Solar Maximum Mission satellite, may have been a factor in this year's unusually harsh winter.

This winter's severe weather conditions in the United States, coupled with the new results, may be the first direct observation of a cause and effect relationship between the Sun's energy output and changes in Earth's weather and climate.

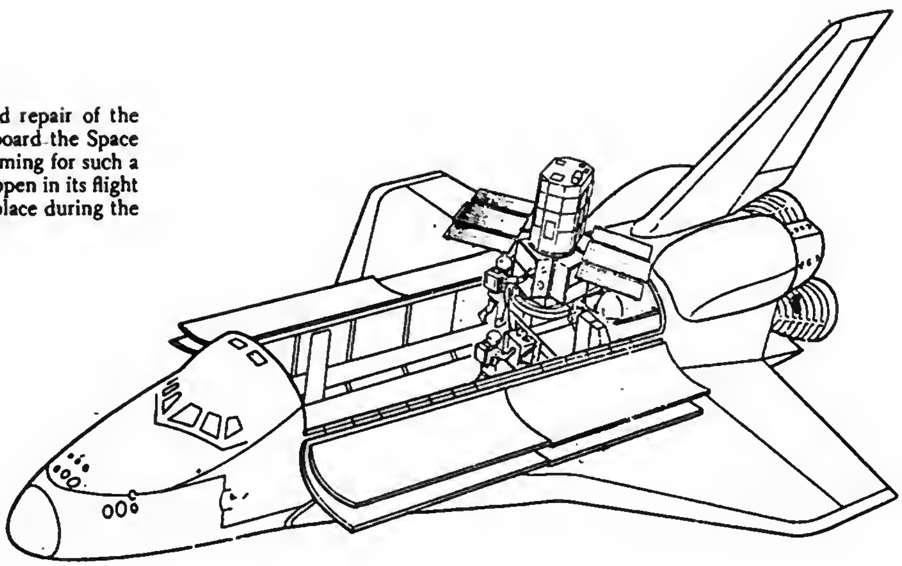
A persistent decrease of a tenth of a percent in the total amount of solar energy reaching Earth (solar irradiance) was detected over an 18-month period from February 1980 to August 1981 by the Active Cavity Radiometer Irradiance Monitor experiment on the satellite.

"This is a small change in the total energy output of the Sun, but has great potential significance for the Earth's fragile ecosystem," according to Dr. Richard C. Willson, principal investigator and designer of the experiment, a physicist at the Jet Propulsion Laboratory.

Climatologists are already studying the results of the experiment which will be correlated with such global climate indicators as average temperatures, ice coverage and sea level to evaluate the effects of the drop in solar irradiance.

A systematic increase or decrease in the Sun's release of energy – as little as one half percent per century – can produce vast changes in the Earth's climate. Scientists believe that a one percent decrease would lower Earth's mean global temperature by more than 1°C. According to some models, a decrease in solar energy of less than 10 per cent could effectively freeze the Earth's entire surface.

Nearly all life forms on Earth exist within the 10 km above and below mean sea level. The temperatures within this thin environmental shell, called the biosphere, are determined by the amount of energy received by the Sun and delicate interactions between the atmosphere, ocean and land masses. The climatic effects of short-term variations in solar irradiance are



Artist's concept of the retrieval and repair of the Solar Maximum Mission satellite aboard the Space Shuttle. No money has been forthcoming for such a mission but NASA is keeping a slot open in its flight schedules. The first EVA will take place during the fifth Shuttle mission this November.

moderated by the heat capacity of the ocean and atmosphere.

A long-term increase or decrease, however, can eventually change the temperature of the ocean and atmosphere enough to change the weather and climate. "These kinds of small but persistent trends in solar irradiance are believed to have been causes of climatic changes in the past," Willson said.

Solar magnetic activity reaches a maximum approximately every 11 years. The peak of the current solar cycle (known as solar cycle 21), occurred in early 1980, about the time the Solar Maximum Mission satellite was launched. The irradiance decrease detected by the monitor may be related to the general decline in solar activity since then. However, the decrease might be an indication of a longer-term trend in the Sun's irradiance. Years of careful measurements would be required to identify such a trend.

In its two years of operation, the irradiance monitor also observed short-term increases and decreases, lasting from days to weeks, in the amount of solar energy reaching Earth. Analysis indicates the decreases are the effects of sunspots (dark, cooler patches on the Sun), while increases are caused by faculae (bright, extra-hot solar regions).

The monitor also detected evidence of solar oscillatory phenomena; global pulsations whose effects extend deep into the Sun. The oscillations had a five-minute periodicity. These five-minute oscillations match ground-based observations discovered in the 1970's. Study of this phenomenon, so-called "solar seismology," will provide new information on the inner workings of the Sun that cannot be obtained by other means.

During most of Earth's history, the climate appears to have been considerably warmer, with average global temperatures about 25°C (77°F). The current average global temperature is 15°C (59°F). A gradual trend to a cooler climate began about 100 million years ago, resulting in the glacial climate of the last 20 million years. At least four major glacial epochs, each lasting nearly 100 million years, have occurred in the last 1,000 million years. The last epoch ended 250 million years ago. The present glacial period may yet prove to be another major epoch.

The Solar Maximum Mission was launched on 14 February 1980. In December 1980, after 10 months of normal operation, the satellite's attitude control system lost its capability to point precisely at the Sun. A less precise pointing technique was subsequently achieved by spinning the spacecraft so that it rotates every six minutes. In this configuration, three of the satellite's seven instruments continue to acquire useful data.

The Sun crosses ACRIM's field of view several times per orbit, providing an adequate quality and quantity of data for the experiment's primary mission objectives, though the data are deficient in some solar physics information (like the observation of solar oscillations). While the spin-stabilised pointing allows continued study of the Sun, the satellite's 550 km orbit is slowly decaying due to atmospheric drag. At the present rate of decay, the Solar Maximum Mission satellite will reenter Earth's atmosphere in 1984. Its demise will leave at least a three-year gap in the precise record of solar irradiance observations made for the National Climate Programme. The earliest successor experiment to the irradiance monitor is planned for deployment on NASA's Upper Atmospheric Research Satellite (UARS) in 1987.

Solar Maximum Mission was the first NASA satellite designed to be retrieved by the Space Shuttle. An effort to retrieve the satellite, repair it on orbit and redeploy it in late 1983 is being studied by NASA. The rejuvenated satellite would allow scientists to observe a wide range of solar phenomena in a different part of the solar activity cycle and sustain solar irradiance monitoring with the precision required for climate studies. Authorisation for the proposed Solar Maximum Mission repair mission is currently under consideration by Congress.

VOLCANIC DEBRIS

The stratospheric cloud of debris from Mexico's El Chicon volcano has been observed under NASA's project for the study of the atmospheric effect of volcanic eruptions, writes Gerald Borrowman.

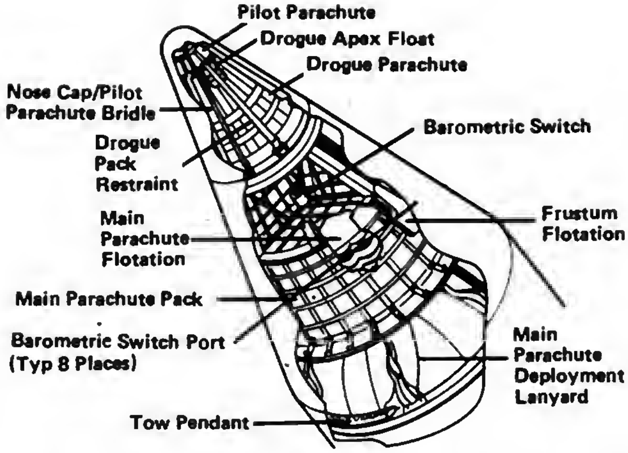
James Pollack of the Ames Research Center and head of its project recently described some of the preliminary conclusions about the total size and density of the hemisphere-wide "monster cloud" and its possible effects on the climate. According to Pollack, "What is very important about El Chicon is that there is much more material in it than even in Mt. St. Helens. Probably the biggest [eruptions] that we've had in the last century have been things like Krakatoa and it's hard at this point to know exactly how El Chicon will compare to the best of them.

"When volcanic material is present it tends to cause the temperatures in the stratosphere to become higher and to

cause a cooling in the lower atmosphere and at the surface. You have to worry about the length of the growing season being somewhat shorter at higher latitudes. Measurements, including some that we've done from our [U-2] aircraft, indicate that somewhere between about a quarter and a half of the sunlight that is falling on the Earth in the northern tropical regions is striking one of these volcanic particles and either being reflected back to space or being reflected back down to the lower atmosphere. A fair amount of it will still reach the lower atmosphere so it's a little bit deceptive in the sense that there is still going to be 25 or 30 per cent less sunlight reaching the lower atmosphere in the tropical region.

"If our suspicions are correct we should start seeing very noticeable increases in the temperature of the stratosphere.

"There is one very nice thing about volcanic clouds [and that is] they cause very pretty sunsets. A lot of the famous English landscape paintings at the end of the 19th century were very strongly influenced by having very brilliant sunsets due to volcanic material. So as the material starts to move northward we should see longer sunsets and towards the end the sky should look a bit purplish."



The loss of the two Solid Rocket Boosters from the fourth Shuttle launch at the end of last June has been blamed on the early firing of explosive bolts attached to the parachute lines. The three previous flights lost some of the parachutes and NASA decided to change the recovery sequence so that they could be sure of retrieving the complete fourth set for examination. The explosives should have fired as the spent rocket hits the water; instead they fired at altitude and prevented the two sets of three parachutes from opening properly. The boosters hit the sea some 100 mi (160 km) from their launch point, and sank in 3500 ft (1100 m) of water. Photographs showed one of them to be broken up, the other appeared to be in fair condition because it entered the water end first.

SHUTTLE LIQUID HYDROGEN

Looking ahead to a regular and busy schedule of Space Shuttle missions, scientists and engineers at the Kennedy Space Center are surveying the technology of liquid hydrogen production and recovery. One result might be the establishment of a manufacturing plant on or near the Center in the future.

Each developmental flight of the Shuttle required about half a million gallons of liquid hydrogen, mostly as fuel for the three main engines.

KSC now obtains its liquid hydrogen from a plant in Louisiana, where it is produced from natural gas and shipped in insulated over-the-road tankers holding 13,000 US gallons each. Starting next spring, it will also be transported in specially designed rail cars holding 34,000 US gallons each.

Liquid hydrogen is a highly efficient and clean-burning fuel; its exhaust plume from combustion with oxygen is pure steam. It is difficult to handle, however, because it must be kept at extremely low temperature (−253°C) or it returns to its gaseous form. In spite of all precautions, a considerable amount is lost to "boil-off."

Teams at KSC are studying methods of producing liquid hydrogen from fossil and non-fossil sources and methods of recovering some of the gasified fuel that is normally lost during transportation and storage.

KSC anticipates using two million US gallons of liquid hydrogen in 1982. James Spears, chief of the KSC special projects development office, however, speculates that by 1990 as much as 15,000,000 US gallons per year might be required for all uses and by the year 2000 perhaps as much as 50,000,000 US gallons.

One group is studying a polygeneration plant that would produce hydrogen and several other forms of energy, starting from a coal gasification unit. The sequence begins with the partial combustion of high-sulphur coal in a pure oxygen atmosphere. Heat from the resulting gas can be used to produce steam, and after additional purification the gas can either be burned itself or processed to extract its hydrogen. Other valuable by-products such as oxygen and nitrogen, used extensively at KSC, are also produced.

A plan to recapture gaseous hydrogen may be used at the liquid hydrogen storage tank on the Space Shuttle's launch pad. Even though the hydrogen is stored in a heavily insulated Dewar container, essentially a giant thermos bottle, some liquid converts to gas and "boils off" at the top of the tank. About 400 US gallons a day are lost this way.

This recovery system would use an electrified wire coil chilled to −262°C to create a magnetic field. The superconducting magnet cyclically magnetises a porous material through which the gaseous hydrogen flows. As the magnetic cycling "pumps" heat from the gas, it again becomes cold enough to liquefy. Normally a compression system is used to energise the gas, but use of the coil requires less electric power to produce the same result in a more compact device.

IN THE PAST

25 Years Ago ...
3 November 1957. The Soviet Union orbits the large Sputnik 2 satellite, carrying the dog Laika, only a month after Sputnik 1. The first US satellite is still three months in the future.

20 Years Ago ...
4 November 1962. Astrochimp Enos, who completed a two orbit flight in Mercury 5 a year ago, dies after an illness at the Holloman Air Force Base in New Mexico.

15 Years Ago ...
9 November 1967. SA-501, the first Saturn 5, is launched from the Cape carrying the Apollo 4 spacecraft. This successful test of three live stages and a spacecraft paves the way to a further 12 launches, including nine lunar missions and the Skylab space station.

10 Years Ago ...
17 October 1972. Astronaut Tom Stafford tries out a Soyuz docking simulator with cosmonauts Nikolayev and Shatalov during a visit to Star Town near Moscow. Stafford was subsequently named as the US commander of the Apollo-Soyuz mission.

5 Years Ago ...
26 October 1977. The People's Republic of the Congo becomes the 100th member of Intelsat.

D. J. SHAYLER

NEWS FROM THE CAPE

By Gordon L. Harris

SECRET OR NOT?

Columbia's fourth and last development launch gave rise to a good-humoured, semi-serious debate between newsmen, and NASA and defence representatives. The dispute involved a Department of Defense payload naively listed as "DOD 82-1" about which Air Force officers would say nothing. Their superiors acknowledged that the cargo would remain in the STS-4 payload bay and that astronauts Mattingly and Hartsfield would perform tasks related to that package. Downlink video, on the other hand, would not disclose the shape, size or location of the cargo nor would the crew talk about it in open air-ground conversation.

Brian Duff, NASA public affairs chief, tried valiantly to convince 1,800 media people covering the 27 June launch that his agency would maintain its "open" policy except for Defense cargo and, which surprised some reporters, "other customers" who prefer not to divulge technical details of their freight. Simply put, NASA will conduct Shuttle business like commercial air carriers; that is, paying users decide how much the public needs to know about their activities.

Brig. Gen. Richard Abel, Air Force information chief, said NASA and DoD agreed that all military cargo assigned to Shuttles will be secret whether or not, by itself, the payload is classified. That should eliminate pinpointing the truly vital secret manifest, he added.

A trade magazine, *Aviation Week*, together with a publication of the American Institute of Aeronautics and Astronautics, described DOD 82-1 in minute detail. A local newspaper picked up this data, phoned the Soviet Embassy in Washington, and learned the Russians subscribe to *Aviation Week* and knew of its account of the military STS-4 package. Whereupon, the local paper disclosed the same data. The Soviet spokesman told his caller that "We're not so foolish."

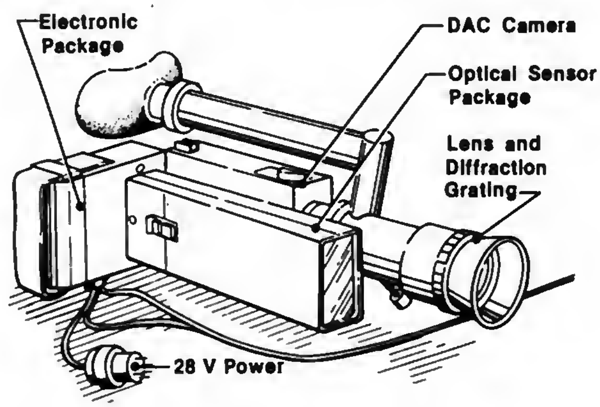
Meanwhile, NASA's latest edition of "payload manifest" lists some 20 DoD missions by Sept. 1987, some flown from Vandenberg Air Force Base in California, the others from KSC. Verbal exchanges between flight crews and the ground will focus on Air Force Satellite Control, not NASA's Mission Control Center.

Air Force Major General James Abrahamson, who is the new NASA associate administrator for Shuttles, told newsmen "this is a national system" available for Defense as well as NASA cargo.

While all of this was in progress, the energetic local newspaper tried unsuccessfully to find out details of an STS-4 experiment sponsored by Johnson & Johnson, a giant pharmaceutical firm. The company refused to divulge its contents or purpose. Hence it appears that US industry can protect secrets more readily than the Department of Defense.

NASA brought STS 4 down at Edwards Air Force Base in California on 4 July, an obvious bid for publicity with the presence of President Reagan. In turn, for a seven-day mission, that meant a Sunday launch on 27 June. Remarkably, none of the media covering the launch asked how much additional cost was involved in a Sabbath spectacular which required payment of double and triple wages to thousands of contractor employees. For example, the company supplying guards at the launch base took on 50 otherwise unemployed people for two days at an hourly rate of $9.87, almost as much as astronauts Mattingly and Hartsfield were paid for the same days.

During its most recent press briefing concerning Shuttle cargo tariffs, Dr. Stanley Weiss of NASA said the four development flights cost "a couple of hundred million (dollars) apiece."



SHUTTLE STORM EXPERIMENT

The Nighttime/Daylight Optical Survey of Lightning (NOSL) experiment was developed for the Shuttle to record lightning discharges within storm clouds. It was carried during STS-2 in March 1982 but the shortened mission allowed little time for significant observations. As a result, NOSL was reflown on STS-4 and will travel aloft again on STS-6.

The components for the NOSL experiment are a 16 mm Data Acquisition Camera (DAC), 17 to 85 mm zoom lens, stereo cassette tape recorder, sensor package assembly, cable assemblies, earphone, cassettes, etc. The camera obtains top view photographs of the weather systems that make up severe thunderstorms or tornados. During the nighttime portion of an orbit, a diffraction grating is attached to the camera to provide lightning spectrographic data for temperature, pressure, molecular species, electron density, and percentage of ionization information within the lightning's path. In addition, the amplitudes and durations of the discharges are detected simultaneously by a photocell optical system. The signals from that system are recorded on one track of a two-track magnetic tape recorder and, at the same time, will provide an audio signal in the astronaut's earphone. The verbal description of the storms are recorded on the other track.

A lightning event which appears visually as only one flash is usually composed of many separate discharges, or strokes. These can be detected by the photocell and the frequency of the lightning and its characteristics during day or night can be correlated with the observed cloud structure and the convective circulation in the storm. These techniques may prove to be useful for identifying severe weather situations from meteorological satellites.

THE FRENCH SPACE BUDGET AND PROGRAMMES (1982)

By Clive Simpson

Introduction

French national space policy was reviewed in its entirety at the time of the European Council meeting in October 1981 which authorised the following new programmes: Ariane IV, ERS 1, Spacelab follow-on development, Microgravity and SPOT 2. The French also agreed to the setting up of the SPOT Image company and to provide further funding in support of export activities.

The 1982 Budget

The French national space agency (CNES) budget for 1982 amounts to 3,013.303 million francs (MF) against 2,538.106 MF for the initial 1981 budget, representing an increase of some 18.7 per cent. Within this, the total state subsidy for 1982 is 2,545.485 MF, broken down into 2,218.370 MF for programme appropiations and 327.115 MF operating subsidy.

Trends within the budget itself show that the French *national* programme is now receiving 20.9 per cent of the money, compared to only 8.7 per cent in 1980, and the figure for multilateral cooperation has decreased from over half to 31.7 per cent. This continues the effort to restore the balance between multilateral and the national and bilateral programmes started in previous years.

The French national programme budget for 1982 shows an increase of more than 80 per cent over 1981, mainly due to the Earth Observation Test Satellite (SPOT) programme for which expenditure will peak this year.

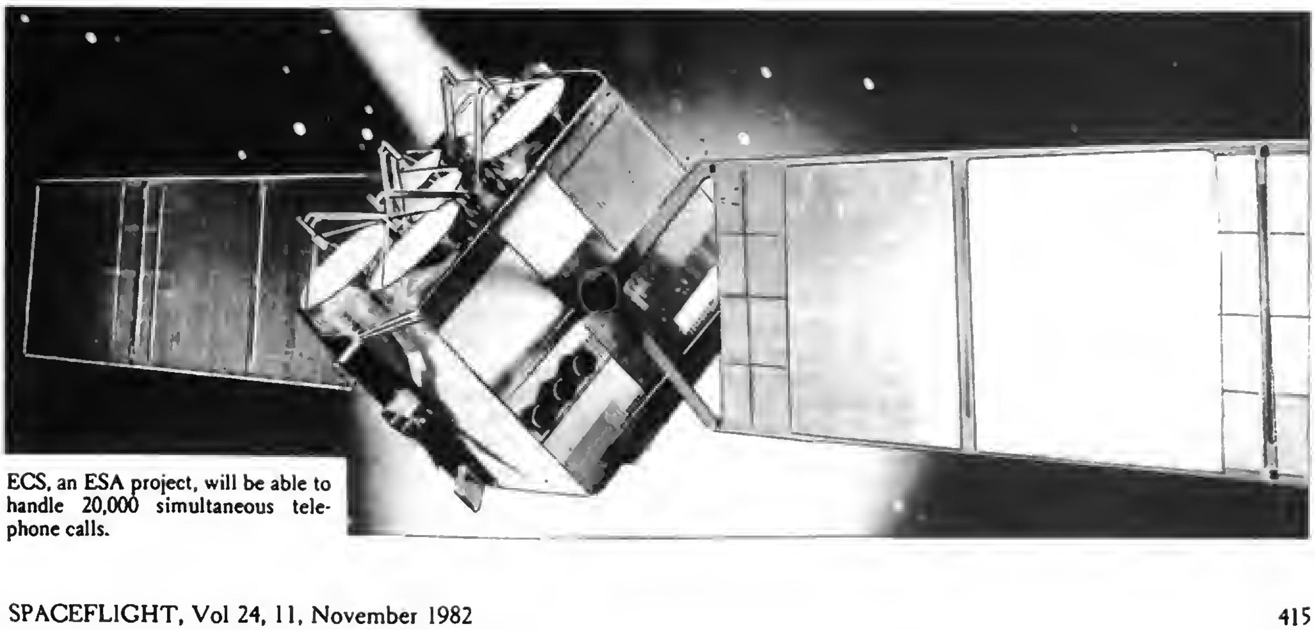
Launching and positioning of the SPOT 1 satellite in a Sun-synchronous orbit by an Ariane launch vehicle is planned for 1984. Its main task will be to explore Earth resources, detect and forecast climatology- and oceanology-related phenomena and to monitor natural phenomena and activities. In October 1981 the setting up of SPOT Image was approved, a commercial organisation with a majority state holding for the marketing of SPOT data.

In the applications field the French national communications satellite programme, approved in 1979, is designed to enable the Telecommunications and Post Office Administration to meet growing domestic requirements for conventional services and to provide new services.

The SPOT (Satellite Probatoire d'Observation de la Terre) remote sensing satellite is planned for launch in 1984 by Ariane.

CNES

CNES contributes to launch vehicle funding and the Ceneral Telecommunications Authority provides the bulk of the expenditure. Ariane is scheduled to launch TELECOM 1A in July 1983 and TELECOM 1B the following October.



ECS, an ESA project, will be able to handle 20,000 simultaneous telephone calls.

France is the major contributor to the Ariane launcher project. The 1982 budget allocation is for some 290 million Francs.

ESA

Funds allocated to the national space programme (excluding research and development) amount to 628.650 MF, broken down into 6.200 MF for science; 16.100 MF for telecommunications, 590.750 MF for Earth observation and 15.600 MF for space vehicles.

There is a total of 95.050 MF for research and development to cover such programmes as the Solaris system, a project consisting of a permanent station, an Earth-to-orbit station and a maintenance module. Studies will also be made of a geostationary data relay system and the use of automatic in-orbit intervention and robotics.

The 1982 CNES budget allocates a total of 475.850 MF to bilateral cooperation, funding which is within 1.9 per cent of the previous year's figure after 1981's sharp rise.

In addition to cooperation with the rest of Europe and NASA in various scientific and applications projects there is considerable Franco-Soviet interaction. In fact, under this heading 14.000 MF alone is allocated to the joint Franco-Soviet manned flight, a mission to put the first French astronaut in space onboard a Salyut space station by the middle of this year.

Another joint venture with the Russians is the Venus exploration project (VEGA), which since modification in October 1980 consists of a Venus lander and also a probe to Halley's Comet. The scheduled launch date is in 1984 for a rendezvous with Venus in 1985 and Halley's Comet in 1986.

Halley's Comet comes in for further study under French cooperation with ESA, the European Space Agency, and experiments being carried on the Giotto probe due to be launched by Ariane II in July 1985. French laboratories will take part in experiments involving photographing the comet with a multispectral camera, study of chemical composition of neutral and ionised gases by mass spectrometry, study of the comet's ionised environment, and study of the comet dust by photo-polarimetry.

French experiments will also be flown in the first Spacelab payload, at present planned for launch by the Space Shuttle in September 1983. These experiments cover the fields of material sciences, atmospheric physics, biology and astronomy.

In addition to a few scientific experiments, mainly concerning auroral physics, material science and interferometry, cooperation with the Federal Republic of Germany is being developed in the communications sector with the Symphonie direct broadcasting programmes. This project provides for the production of two geostationary satellites, one for each country, and the launch of the French satellite by Ariane will take place in 1985.

Funds allocated under the heading of European multilateral cooperation also cover the French contribution to the various ESA programmes and, apart from the Ariane launch vehicle (which is due to receive 290.40 MF from a planned 951.55 MF contribution), the European programmes include both applications and scientific projects, as well as Spacelab. If Ariane and Spacelab are included, the applications programmes represent about 80 per cent of this contribution.

The Ariane programme, undertaken in 1973 with CNES as the prime contractor, is already proving to be a major competitor to American launch systems, including the Shuttle, and should ensure Europe's independence as regards launch facilities for the next decade.

In the telecommunications field the launch by Ariane of the first ECS system, designed to provide long distance telephone, telegraph and telex links inside Europe, as well as "Eurovision" type television programme exchange, is planned for the second half of 1982.

Earth observation programmes which fall in the cooperation with ESA category include Sirio 2, a meteorological data and clock synchronisation experiment, due for launch in the first half of this year, and ERS 1, a scientifically-orientated programme focussed on research into climatology, oceanography, glaciology and marine biology, which will complement fields already covered by SPOT. The first launch is planned for 1987.

Among other ESA projects receiving French support are Exosat, the European X-ray observatory satellite planned for launch later this year; the American Space Telescope solar arrays, faint object camera and photon detector; and Hipparcos, the astrometry satellite designed to determine the trigonometric parallaxes, proper motions and positions of 100,000 stars.

Conclusions

The restoration of a balance between multilateral cooperation and the national and bilateral programmes started in previous years is achieved in 1982 with the industrial implementation phase of large projects, such as SPOT and direct broadcasting, and the completion of the Ariane development programme.

In parallel, preparation for future programmes is actively underway, coupled with a research and development effort to support exports with the intention of placing French industry in the forefront of international competition. It also aims to build on the success already achieved in the marketing of Ariane, in the prospecting associated with the distribution of SPOT data and in the production of telecommunications systems.

SATELLITE DIGEST — 158

Robert D. Christy
Continued from the September/October issue

A monthly listing of satellite and spacecraft launches, compiled from open sources.

The heading to each launch gives the name of the satellite or craft, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes, except where marked with an asterisk, where the time is to the precise minute as announced by the launching agency.

COSMOS 1356 1982-39A, 13153

Launched: 0810, 5 May 1982 from Plesetsk by A-1.
Spacecraft data: Possibly based on the Meteor satellites with a cylindrical body and two, Sun seeking, solar panels. Length around 5 m and diameter around 1.5 m, mass approx 2500 kg.
Mission: Electronic reconnaissance.
Orbit: 632×671 km, 97.79 min, 81.19 deg.

COSMOS 1357–1364 1982-40A-H, 13160-13167

Launched: 1800, 6 May 1982 from Plesetsk by C-1.
Spacecraft data: Probably spheroidal in shape, mass about 40 kg each.
Mission: To provide tactical communications between troops or units in the field.

Big Bird 1982-41A, 13170

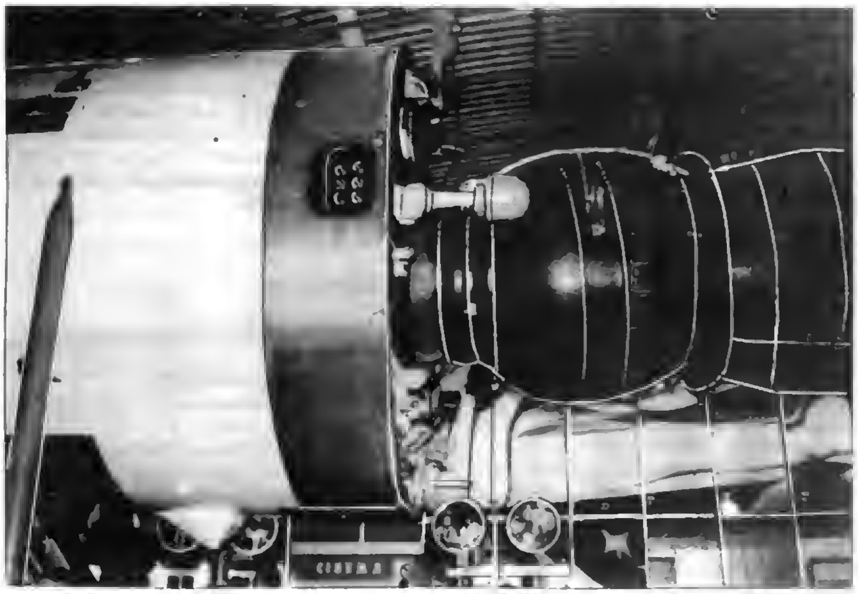
Launched: 1845, 11 May 1982 from Vandenberg Air Force Base, Western Space and Missile Center by Titan 3D.
Spacecraft data: Cylinder with antennae and solar panels, and containing re-entry capsules for film recovery, length 15 m and diameter 3 m with mass around 13000 kg.
Mission: Military photo-reconnaissance.
Orbit: Initially 177×262 km, 89.91 min, 96.41 deg, manoeuvrable.

HITCH HIKER 1982-41C, 13172

Launched: Pick-a-back with Big Bird.
Spacecraft data: not available.
Mission: Electronic reconnaissance.
Orbit: 701×707 km, 98.87 min, 95.99 deg.

SOYUZ-T5 1982-42A, 13173

Launched: 0958, 13 May 1982 from Tyuratam by A-2.
Spacecraft data: Standard Soyuz-T design consisting of a near-spherical orbital module, conical re-entry module and cylindrical instrument unit. Length about 7.5 m, max diameter 2.2 m and mass around 6500 kg.
Mission: Ferry vehicle carrying long stay crew of Anatoly Berezovoi and Valentin Lebedev to Salyut 7 (1982-33A).
Orbit: Initially 192×231 km, 88.66 min, 51.60 deg but altered after 6 hours to a transfer orbit of 269×325 km, 90.40 min, 51.59 deg. After docking with Salyut 7 at 1136 on 14 May the orbit of the complex was 343×356 km, 91.35 min, 51.59 deg.



A mock-up of a Progress supply ship attached to the (now decayed) Salyut 6 space station. See "Progress 13" entry.

P. Mills

COSMOS 1365 1982-43A, 13175

Launched: 1925, 14 May 1982 from Tyuratam by F-1.
Spacecraft data: not available but probably several tonnes mass.
Mission: Military reconnaissance using radar powered by a nuclear reactor.
Orbit: Initially 252×264 km, 89.65 min, 65.00 deg and maintained constantly near that height by an onboard low thrust motor.

ISKRA 2 1982-33C, 13176

Launched: 17 May 1982 from an airlock aboard Salyut 7.
Spacecraft data: Roughly spherical, approx 0.5 m diameter and covered with solar cells; mass 28 kg.
Mission: Amateur radio relay.
Orbit: Initially 342×336 km, 91.27 min, 51.59 deg, decayed after 81 days on 9 July.

COSMOS 1366 1982-44A, 13177

Launched: 2345, 17 May 1982 from Tyuratam by D-1-E + apogee motor.
Spacecraft data: Probably similar to the Gorizont satellites, namely a cylinder with a pair of solar panels, one either side. Length around 5 m and max. diameter around 2 m. The mass is around 2000 kg.
Mission: Experimental communications satellite, probably connected with the planned Luch series.
Orbit: Initially a low parking orbit at 51.6 degree inclination and then injected into an elliptical transfer orbit at 47 degree before going into a geostationary drift orbit. Later stabilised above 90 degree east longitude.

COSMOS 1367 1982-45A, 13205

Launched: 1310, 20 May 1982 from Plesetsk by A-2-e.
Spacecraft data: Probably similar to the Molniya satellites.
Mission: Part of the USSR's system of missile early warning satellites.
Orbit: Initially a low parking orbit and then injected into a highly elliptical one of 581×39264 km, 707.44 min, 62.86 degrees.

COSMOS 1368 1982-46A, 13208

Launched: 1240, 21 May 1982 from Tyuratam by A-2.

Spacecraft data: Possibly based on the Vostok manned spacecraft with spherical re-entry module, instrument until and a cylindrical, supplementary payload at the forward end. Length about 6 m, diameter (max.) 2.4 m and mass around 6000 kg.
Mission: Military photo-reconnaissance.
Orbit: Initially 211×341 km, 90.04 min, 70.37 degree then manoeuvred. Recovered after 14 days.

PROGRESS 13 1982-47A, 13210

Launched: 0557, 23 May 1982 from Tyuratam by A-2.
Spacecraft data: Similar in appearance to Soyuz-T except that the re-entry module is replaced by a cone shaped, non-recoverable compartment for stores. Mass 7000 kg.
Mission: To carry supplies to the resident crew of Salyut 7 and to deliver experimental equipment for the planned Soyuz-T6 mission.
Orbit: Initially 191×278 km, 88.9 min, 51.6 degrees then via an intermediate transfer orbit to that of Salyut 7. Docking with the rear unit of Salyut took place on 25 May. Progress 13 undocked from Salyut 7 on 4 Jun at 0631, it was de-orbited by a retro rocket firing at 0405 on 6 Jun.

COSMOS 1369 1982-48A, 13213

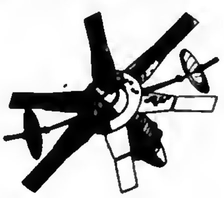
Launched: 0850, 25 May 1982 from Plesetsk by A-2.
Spacecraft data: see Cosmos 1368.
Mission: Photo-reconnaissance, all or part of the payload was an Earth Resources package, recovered after 14 days.
Orbit: Initially 269×276 km, 89.98 Min, 82.31 degrees, then manoeuvred.

COSMOS 1370 1982-49A, 13219

Launched: 0910, 28 May 1982 from Tyuratam by A-2.
Spacecraft data: Probably similar to Cosmos 1368.
Mission: Military photo-reconnaissance, recovered or re-entered after 44 days.
Orbit: Initially 197×275 km, 89.22 min, 64-85 degrees then manoeuvred several times.

MOLNIYA-1(54) 1982-50A, 13237

Launched: 2205, 28 May 1982 from Plesetsk by A-2-e.
Spacecraft data: A cylindrical body housing instrumentation and the payload, surmounted by a conical motor section. Power is provided by a "windmill' of six solar panels. Length 3.6 m, diameter 1.6 m, mass around 1800 kg.
Mission: Communications satellite helping to operate long distance telephone and telegraph communications, and the broadcasting of Central television programmes to Orbita receiving stations in the Soviet far north, Siberia, the Soviet far east and central Asia.
Orbit: Initially a low parking orbit, then injected into a highly elliptical one of 627×40631 km, 736.13 min, 62.83 degrees, later lowered slightly to 718 mins to ensure daily repeats of ground tracks.



COSMOS 1371 1982-51A, 13241

Launched: 0435, 1 Jun 1982 from Plesetsk by C-1.
Spacecraft data: May be similar to the navigation satellites, i.e. a cylindrical body with domed ends, enclosed in a cylindrical solar array with length and diameter around 2 m. The mass may be around 700 kg.
Mission: military communications using a store dump technique.

COSMOS 1372 1982-52A, 13243

Launched: 1355, 2 Jun 1982 from Tyuratam by F-1.
Spacecraft data: see Cosmos 1365.
Mission: Military reconnaissance using radar powered by nuclear reactor.
Orbit: Initially 246×270 km, 89.65 min, 64.99 degrees and maintained constantly near that height by an onboard low thrust motor.

COSMOS 1373 1982-53A, 13244

Launched: 1300, 2 Jun 1982 from Tyuratam by A-2.
Spacecraft data: As Cosmos 1368.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: Initially 210×347 km, 90.08 min, 70.38 degrees then manoeuvred.

COSMOS 1374 1982-54A, 13257

Launched: 2125, 3 Jun 1982 from Kapustin Yar by C-1.
Spacecraft data: Speculative, but some western reports suggest a delta winged re-entry vehicle attached to a retro-rocket, mass around 1000 kg.
Mission: Re-entry test, the craft was recovered in or over water at the end of one orbit.
Orbit: 225×225 km, 50.66 degrees.

COSMOS 1375 1982-55A, 13259

Launched: 1705, 6 Jun 1981 from Plesetsk by C-1.
Spacecraft data: Not available.
Mission: Target for interception test.
Orbit: 981×1011 km, 105.02 min, 65.84 degrees.

COSMOS 1376 1982-56A, 13263

Launched: 0800, 8 Jun 1982 from Plesetsk by A-2.

Spacecraft data: See Cosmos 1368.
Mission: Photo-reconnaissance, all or part of the payload was an Earth Resources package.
Orbit: Initially 261×274 km, 89.88 min, 82.34 degrees then manoeuvred. Recovered after 14 days.

COSMOS 1377 1982-57A, 13265

Launched: 1200, 8 Jun 1982 from Tyuratam by A-2.
Spacecraft data: Possibly as Cosmos 1368.
Mission: Military photo-reconnaissance, recovered or re-entered after six weeks.
Orbit: Initially 173×363 km, 89.86 min, 64.90 degrees then manoeuvred several times.

WESTAR 5 1982-58A, 13269

Launched: 9 Jun 1982 from Eastern Space and Missile Center.
Spacecraft data: Cylinder, approx 3 m long, 2 m diameter.
Mission: Communications satellite.
Orbit: Ceostationary.

COSMOS 1378 1982-59A, 13271

Launched: 1100, 10 Jun 1982 from Plesetsk by F vehicle.
Spacecraft data: Not available.
Mission: Electronic reconnaissance.
Orbit: 634× 663 km, 97.72 min, 82.51 degrees.

BOOK NOTICES

The Discovery of Neptune
M. Grosser, Constable & Co. 172pp, 1978, £1.90.

The disovery of Neptune is one of the most fascinating chapters in the history of astronomy. The dramatic history of the two independent predictions which led to this, one by a French astronomer and the other by a young English mathematician, is the subject of this well-researched volume.

The author sketches the background of planetary astronomy up to 1781, describing the discovery of Uranus and the discrepancies which were subsequently noted between its observed and theoretical positions. Chapters are devoted to the men who used these discrepancies to calculate the position of the still undiscovered perturbing planet. Neptune was found in September 1846, but the fact that this was done by a Berlin observatory and not by Challis at the Cambridge Observatory was the cause of bitter conflict which arose over claims for priority in predicting the new planet's position, and the honour of its discovery. The volume concludes with an account of the first meeting of the two rival claimants which led, eventually, to firm friendship.

The Story of the Space Shuttle (2nd Edition),
Tim Furniss, Hodder & Stoughton, 106pp, 1982, £3.95 (soft cover).

Tim Furniss, an Associate Fellow of the Society (as he does us proud by noting on the back cover) has updated his earlier edition, which was published before the Shuttle first flew. The book is in an "easy-reading" format, with plenty of photographs and drawings to take us through the history of the Shuttle, the people who fly (or will fly) it, and the many plans for future developments based on its use.

There are several pages of full colour illustrations, and the text is concise and packed with information. This is not a book for the expert, or for those seeking technical details, but as a popular account to "dig into", it contains much for the layman.

There are chapters devoted to Spacelab, the ground station from which the Shuttle will operate (and to which it will return), the early missions (the book includes STS-2, with STS-3 "due soon'), and "making space work", a useful look ahead to what is planned (and dreamed of) for the Shuttle's future.

Searching Between the Stars
L. Spitzer, Jr. Yale University Press, 179pp, 1982, £17.50.

During the last decade new observational tools have led to spectacular advances in our knowledge of the interstellar medium.

The author, one of the world's leading authorities on the subject, focuses on this and synthesizes the results into a preliminary model of the interstellar medium and the processes of star formation.

The book begins with a discussion of the cosmic cycle, explaining how physical properties of the interstellar gas are responsible for stellar formation. Much of this knowledge came from the Copernicus satellite, which maintained the Princeton telescope and instrumentation 500 miles above the Earth's surface for almost nine years, detecting ultraviolet radiation from the stars and measuring the absorption produced by the atoms and molecules between them.

Life in the Universe
Ed. J. Billingham, MIT Press, 461pp, 1982, £14 cloth, £8.75 paper.

This volume records the proceedings of a conference on Exobiology held at NASA Ames Research Center in 1979 designed to consider broad questions of life in, roughly, a chronological sequence. This involved dealing, in turn, with theories of the physical and chemical events in the story of cosmic evolution, the environments in which life may emerge and evolve and the evolutionary patterns leading to complex biological systems, including intelligent being, and ending finally with the possibility of extraterrestrial life-forms.

The 29 contributions are grouped in these four main areas, all of which are given roughly equal prominence. The result is that the evolution of extraterrestrial life occupies about one half of the book, with considerable speculation on how complex life-forms might evolve on planets circling other stars and their subsequent manifestation and identifiability.

The volume is a most authoritative compilation, extremely well printed and eminently readable. Extensive references are given, with the result that this volume, as a whole, represents a most valuable addition to the literature.

Voyages to Saturn
D. Morrison, NASA SP-451, US Government Printing Office, 227 pp., 1982, $9.50 (Overseas $12).

This book presents the stories of each of the Voyager encounters with Saturn, Voyager 1 in November 1980 and Voyager 2 in August 1981. Both craft were outstanding successes, returning far more new information than that collected in the preceding 300 years of Earth-based observations. Both probes were risky ventures, involving intricate mechanisms sent to perform delicate measurements after traversing immense distances through space and surviving unexplored fields of particles of magnetic forces.

The book begins with a brief history of Saturn from ancient times and a discussion of the Pioneer probe at Saturn in 1979. The main text of the book then follows, concerned with the two Voyager missions, and ending with a summary of the knowledge gained which has brought about a virtually new concept of the Saturnian system.

The volume ends with appendixes which detail the members of various Voyager teams and provide pictorial maps of some of Saturn's satellites. It also includes an index and reproduces almost 200 images, a third of which are in colour.

The Sun
Iain Nicolson, Mitchell Beazley, 96 pp., 1982, £6.95.

Our Sun, the only star whose surface can be observed directly from Earth, holds the key to understanding some of the fundamental processes at work not only in its own interior but also in those of other stars. The extreme conditions which prevail in and on the Sun, beyond those attainable in any terrestial laboratory, provide a valuable check on scientific theories, while its continuous surface activity makes it one of the most fascinating astronomical bodies to observe.

Ever since the discovery of sunspots in the early 17th Century it has been known that the Sun is not a perfect, unblemished orb, but it is only with the results from Skylab and the Solar Maximum Mission that the full range of solar phenomena has begun to be appreciated. For example, X-ray and ultraviolet radiation, not accessible to Earth-based observers, have revealed new aspects of solar behaviour.

This book summarizes some of the latest scientific findings and discusses the Sun's influence on the Earth and its climate.

The Cosmic Serpent
V. Club & B. Napier, Faber & Faber, 299 pp., 1982, £12.50.

This book attempts to bring together hitherto unconnected strands in astronomy, biology, geology and in the early history and mythology of man, its title providing the unifying theme by referring to an assumed giant comet which terrorised man in prehistoric times. The basis for this lies in knowledge that comets have certainly been regarded as portenders (if not the actual agents) of destruction and disaster upon the Earth until comparatively recent times.

The authors bring together a battery of modern knowledge gathered by radio telescopes, satellites and the like to try to unveil, step by step, an interpretation of Man's past and his somewhat hazardous future. The authors are already known for something of the sort for it was their paper published in Nature some time ago that introduced the idea of an asteroid impact on Earth to explain the rapid extinction of the dinosaurs.

The authors introduce many new concepts. They argue that the

impact of asteroids has been a major force in shaping the evolution of the Earth's biosphere. Many orthodox theories are questioned, with the evolution of spiral arms in nebulae and the origin of comets as examples. A radically new chronology is proposed in archaeology, with the result that even the Old Testament prophets come within the scope of their enquiry.

Observatories of the World

S. Marx and W. Pfau, Blandford Press, 200 pp., 1982, £8.95.

For generations, the world's observatories have been at the forefront of space exploration, producing absorbing programmes of research and a wealth of sophisticated equipment.

This volume selects 40 observatories spread around the world and paints a fascinating picture of the way in which they are contributing to our ever-expanding knowledge of space and time. Details of the main programmes of work and the instruments in use are detailed for each observatory. Besides this, the book lists the major astronomers and important discoveries associated with each observatory.

Naturally enough, more detailed reports of the work undertaken is normally published by the observatory itself or reported in the astronomical literature. However, the general reader has hitherto been denied a good opportunity to obtain an overall view of astronomical work at the present time. This volume fills that gap.

The book is exceedingly well written and will provide hours of absorbing reading for amateur astronomers everywhere.

The Channels of Mars

V. R. Baker, Adam Hilger Ltd., 224 pp, 1982, £22.50 (distrib. in USA by University of Texas Press, $39.95).

A great deal of work, based on images returned to Earth by the Mariner 9 and Viking space vehicles, has been concerned with the interpretation of Martian surface features. Our conceptions of the planet have been irrevocably altered in the light of the enormous amount of factual data which has now become available on a wide variety of surface features.

This volume summarizes these findings in a highly readable style, detailing the scientific reality of ancient volcanic mountains, vast chasms and water-cut channels much larger than any similar features on Earth.

On the basis of morphological evidence, the author offers the hypothesis that some of the largest channels were formed by powerful catastrophic floods that cut through the now arid Martian surface. The book also summarizes the considerable new data on Martian geology and landforms derived from recent space missions. Over 100 NASA images and many interpretive maps and figures are included.

This book will appeal not only to specialists, but to anyone interested in planetary geology or in the origin of landforms.

International Space Technical Applications

Eds. A. Adelman & P. M. Bainum, AAS, 186pp, 1981, $30 (Hard Covers) $20 (Soft Covers).

This is Vol. 52 in the AAS science and technology series. The text is based on the papers presented at the 19th Goddard Memorial Symposium which dealt with concepts which will become feasible with the introduction of a fully operational Shuttle system.

The symposium consisted of eight sessions. Selections from six of these appear in the present volume. They cover such topics as applications to industry, Landsat programmes, communications, weather and climate, and other space-based Earth Science applications, as well as space-based manufacturing and power generation.

Oceanography from Space

Ed. J. F. R. Gower, Plenum Publishing Co. 978pp, 1981, $95.

Even two decades ago, many of the meteorological and oceanographic capabilities of satellites still seemed futuristic technology. Today, satellites can measure and record a wide variety of information about the seas, ranging from chlorophyll content to ocean currents.

This volume attests to the surge of new information, technologies and ideas, and reflects the recent successful demonstrations of remote ocean sensing undertaken by such satellites as SEASAT, Nimbus 7 and others. It provides a comprehensive review of the techniques available from studying the oceans from space and includes a wide variety of examples of such applications. Among the topics dealt with are satellite altimetry, the remote sensing of ice, passive microwave observations, radar studies of the sea surface, water colour measurements and infrared temperature measurements.

This is a well-researched volume which will prove invaluable to oceanographers, marine biologists, meteorologists and specialists in many other areas of remote sensing, instrumentation and pattern recognition.

Astronomical Phenomena for the Year 1983

HMSO, 71pp, 1980, £2.00.

This volume, basically, consists of extracts from the yearly "Astronomical Ephemeris" and includes all the basic data of interest to astronomers. There are tables showing the elongations and magnitudes of various planets, a Diary of 1983 phenomena, sunrise and sunset, moonrise and moonset, plus additional information, with maps, of the 1983 eclipses.

This is one of a number of volumes issued by HMSO concerned with positional astronomy. Also available annually are such related volumes as the *Astronomical Almanac*, *Apparent places of Fundamental Stars*, and *Ephemerides of Minor Planets*.

Revealing the Universe

Eds. J. Cornell and A. P. Lightman, MIT Press, 246pp, 1982, £12.25.

In astronomy, as for other sciences, theories which are isolated from confirmation by observation are an intellectually dead-end and cannot reveal the nature of the real Universe. Observations, too, which lack the theoretical framework, are simply a collection of disorganised facts.

Theory and observation must be married, and frequently checked, if real progress is to be made.

This is a volume by a number of distinguished contributors who have attempted to do just this with some of the most recent exciting developments in modern astrophysics, such as the energy dynamo powering the Sun, the X-ray sky, the nature of quasars, pulsars and cosmic bursters, the evolution of the solar system and the age and structure of the Universe. All are presented in this broader context to demonstrate how the process of scientific discovery works.

Most readers will no doubt, turn to the last pages first, in which three problems still to be solved are posed. The first concerns the number of planets in the Solar System (are there any more?) the second asks if the theory of stellar evolution is wrong and the third ponders on the continuing problem of white dwarfs, neutron stars and black holes, all of which have negligible luminosities and seem to form the tail end of the stellar chain.

Guidance & Control 1981

Ed. E. J. Bauman, AAS, 506pp. 1981. $60 Hard Cover, $50 Soft Cover.

This book, Volume 45 in the AAS series entitled "Advances in the Astronautical Sciences", is divided into five main sections which serve to update developments in guidance and control, with emphasis on magnetic altitiude control, technical story-board display, new developments in spacecraft control components, test, simulations and flight experience.

Particularly interesting is the paper on the recovery of the HEAO-2 satellite. In August 1980, after serving nearly double its original design life, the observatory suffered a simultaneous double failure which ended its normal operation. The procedures employed to bring it back to operational use are described though final verification of the technique was never completed because one of the "failed" gyros unexpectedly revived once more.

Some of the above notes are not reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

TERRAFORMING MARS?

Issues of both *Spaceflight* and *JBIS* this year have carried articles on the possibility of turning Venus into an Earth-like planet. Now, in this October's "Space Chronicle" Journal, Christopher McKay of the Dept. of Astro-Geophysics at the University of Colorado, considers the problems of terraforming our other planetary near-neighbour, Mars.

Other papers in the same issue include a survey of our knowledge of the Sun, a look at Soviet geosynchronous satellites, "Project Farside" and an unusual view of German involvement with the US space programme.

For those of a more mathematical bent, the August Journal was the second "Orbital Dynamics" issue under the editorship of Dr. King-Hele of the Royal Aircraft Establishment at Farnborough. Papers deal with satellite lifetime predictions, satellite clusters, photographic observations and analyses of the orbits of two satellites. Two shorter items discuss the problems of overcrowding in orbit and "unidentified" satellites of 1966.

Issues of the Journal are available at a cost of £1.50 each from the Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Road, London, SW8 1SZ.

WE ARE SEEKING MATERIAL ON NEW AND ADVANCED SPACE CONCEPTS

Our Society enjoys a high reputation as the originator or pioneer of many Space concepts. These reflect the inspiration of our members, hence our need for material of this kind to publish in our magazines.

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Spaceflight. Forward-looking articles covering future exploration and colonisation of the Solar System, new or advanced space applications, journies to the stars, etc.

Articles should be around 2,500 words in length, with good photographs and line drawings. We want *Spaceflight* to be as eye-catching and informative as possible.

Space Education. Already established as an intriguing magazine carrying material of educational value. If you are involved in any aspect of education, either in the UK or abroad, why not consider contributing news, comments or features? *Space Education* is unique. It brings together everyone with an interest in advancing public awareness on Space.

JBIS enjoys an enviable worldwide reputation. We are particularly interested in seeking material for the "Space Technology" issues on technical aspects of astronautics related to space vehicles, materials, communications, lunar and planetary studies, propulsion, guidance and control, instrumentation, experimentation, advanced concepts, applications, etc.

JBIS "Interstellar Studies" issues are particularly well-known for their authoritative articles on all facets of human expansion into the Cosmos.

JBIS "Space Chronicle" issues publish material in the range between *Spaceflight* and specialised areas. Every member will enjoy reading it. Full-length versions of articles in *Spaceflight* are often featured, along with many semi-historical features.

JBIS "Astronautics History" issues concentrate on the historical side of space exploration.

SOCIETY NEWS

SOCIETY VISIT

British Aerospace Dynamics Group, Space and Communications Division was at home to members of the Society's Space Technology Committee visit to Stevenage last June. The group included three members of the Council: P. J. Conchie, R. Parkinson and G. Webb, as well as the Executive Secretary, Len Carter.

The object of the visit was to provide an update on the work of the Division. A full and interesting programme had been arranged, beginning with a welcome by G. W. Childs, Chief Engineer, and followed by a presentation on some of BAe's current space activities by C. H. Martin (Mart), Assistant Chief Engineer. The group was then taken on a tour of the factory.

BAe at Stevenage is the most active centre for space work in the UK; it employs 1,300 people at Stevenage working totally on space activities, and another 200 at the Bristol site. The space interests of BAe are surprisingly wide; the Division's roots go back to 1955 when work started on the Blue Streak Ballistic Missile. This project was cancelled as a weapon in 1960 when it was converted into the first stage of a satellite launcher, Europa 2, for ELDO. Some 11 successful launches of this first stage launch vehicle were made but it was cancelled in 1972 due to lack of UK government support. At this time, ELDO was amalgamated with ESRO to form ESA.

The work on Europa 2 clearly paved the way for the later European Ariane launch vehicle. In the early 1960's, in parallel with the launcher activities, work started on several satellite programmes which led to the design and manufacture of satellites such as UK 3, UK 4 and ESRO 2.

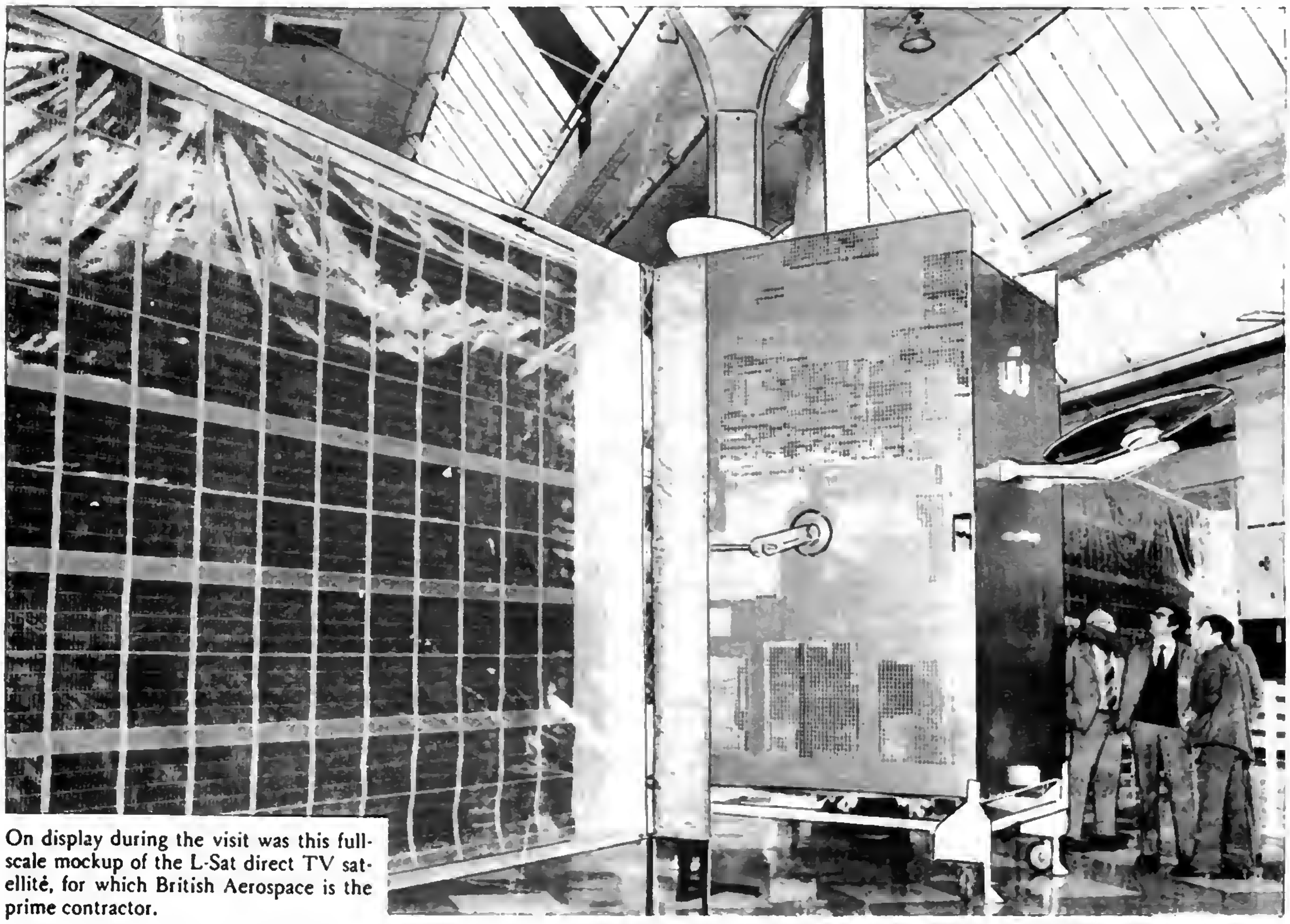
Space is now very much a commercial operation, particularly in the field of communications satellites which currently represent the main market for BAe's products. The Division has many projects running at the same time, ranging from new technology development programmes to Prime Contractorship on small scientific satellites and several major programmes.

MARECS A was launched by ESA just before Christmas and accepted by INMARSAT as an operational satellite for maritime communications on 1 May. It is currently operating over the Atlantic ocean. MARECS B was due to be launched this September for use over the Pacific Ocean. BAe is Prime Contractor for these spacecraft with MSDS as contractor for the payload.

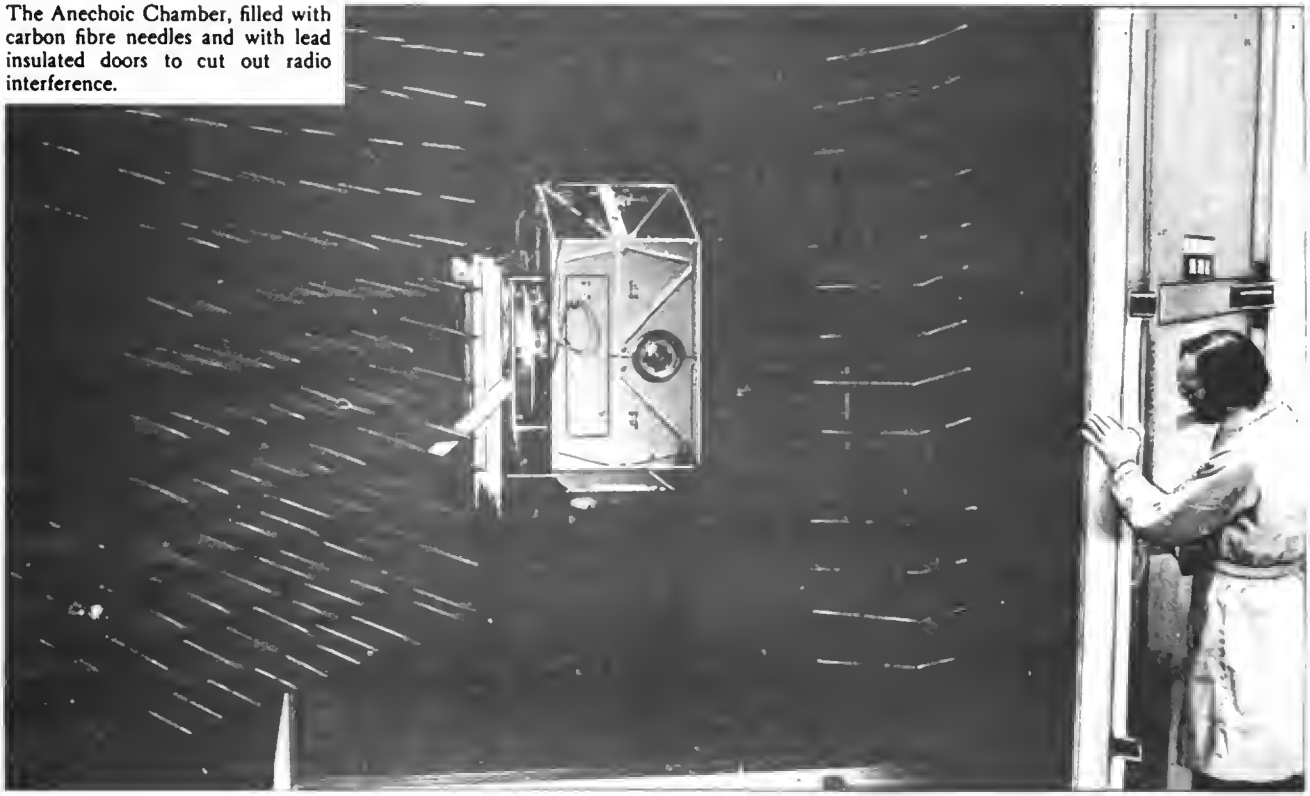
Another ESA programe which uses the same size satellite bus is the European Communications Satellite (ECS). Five satellites are on order, to be operated by EUTELSAT. The first is expected to be launched towards the end of this year.

Another satellite in the small Commsat family is Skynet 4 which is currently being planned for the UK Ministry of Defence. The Division also supplies equipment for the French National Telecommunications Satellite, Telecom 1, with MATRA as Prime Contractor.

A new family of large satellites, based on L-Sat, is currently being developed for ESA. BAe is the Prime Contractor with major suppliers from Italy, Holland and Canada. Several variants of this spacecraft are planned. L-Sat is expected to be launched in 1986.



On display during the visit was this full-scale mockup of the L-Sat direct TV satellite, for which British Aerospace is the prime contractor.



The Anechoic Chamber, filled with carbon fibre needles and with lead insulated doors to cut out radio interference.

BAe have a major involvement in the recently awarded Intelsat 6 programme. This satellite is a very large spin stabilised spacecraft due for launch in 1986. BAe are acting as the sub-contractor to Hughes; the current order is for five spacecraft. Among the responsibilities which BAe have for this programme is the design and manufacture of the satellite cradle which holds the spacecraft in the Shuttle, several antennae dishes and the adapter to hold the spacecraft to the launch vehicle when launched from Ariane. The work also includes the manufacture of the power subsystem equipment, satellite structure and the cable harness.

At Bristol, the Division is designing and manufacturing the large solar arrays for the Space Telescope. This is a project with Lockheed as Prime Contractor and has an operational lifetime of 15 years; it is a joint project between NASA and ESA. Bristol is also the centre for the work as Prime Contractor for ESA on the Giotto probe, due to be launched in July 1985 to intercept Halley's comet in March 1986. This spacecraft is based on the previous ESA satellite, GEOS.

BAe has been the main UK Contractor for the ESA Ariane launch vehicle. This work included the design and development of the third stage LOX/LH_2 pressure control valves, the launcher release gear, solenoid valves, large carbon fibre reinforced plastic struts to hold the engines on the second stage and the protective gaiter shield around the first stage engines.

Currently, work is in hand on equipment for production Ariane vehicles. Work has also started on the new launcher release arms and the front rocket fairing (SPELDA) for Ariane 4.

The BAe Space and Communications Division also build Spacelab Pallets for mounting equipment in the NASA Shuttle bay. Up to five of these pallets can be flown at any one time. Currently, BAe are working on free flying Pallets which can be left in space and later recaptured by the Shuttle. The Pallet is a contender for the Micro-gravity Platform now being defined by ESA.

Study work for ESA is currently in hand within BAe on Hipparcos with MATRA as Prime contractor, and Disco, Magellan with BAe as Prime Contractor. These projects have been recently described in *Spaceflight*.

With Mart's talk behind us the group then turned to the large display area. The uninitiated would be staggered by the immense size of the large communications satellite.

It was hoped to be able to pursuade BAe to agree to display some full size spacecraft at the Space '82 conference in November but even the Brighton Conference Centre may not be large enough. The exhibits currently on display include L-SAT, MARECS, ECS, Skynet and the Microgravity Platform.

After the display visit we were suitably entertained for lunch with talk about space continuing non-stop.

In the afternoon a tour of the facilities was arranged. We visited the large anechoic chamber where communications spacecraft can be tested without going to a full size range. The chamber is the largest in the UK allocated to space use.

The visit to see Pallets in manufacture gave us an impression of the large size but we also learnt of the severe design tests to which these large structures are subjected.

During the visit to the large design centre we saw the CADAM computer-aided design equipment in use. These techniques are allowing for drawings to be speedily prepared and more design options to be analysed. Designers were proficient after one week's basic training and experts after six months. We also saw staff in muffled dress working in the clean room assembling solar array drive mechanisms for Telecom 1 and ECS.

After the tour the party returned to the conference room where a spirited discussion took place with arguments such as "where does the forefront of technology now lie?" It was too much for a hot summer's day in Stevenage.

VISITORS TO HQ

We were very pleased to welcome Gordon Vaeth to the Society's HQ last June. He was on a holiday trip and said he couldn't contemplate coming to London without calling on us.

Gordon, a Fellow of the Society for 31 years now, was an original member of the Project Orbiter team in the mid-1950's. This was the first-planned US satellite programme, later replaced by Project Vanguard. By the late 1950's Gordon was Technical Staff Member for the Man In Space project of the Advanced Research Projects Agency. Now he is Director of Satellite Operation for the National Earth Satellite Service, based in Washington DC, which operates the TIROS and GOES weather satellites. His office has two Command and Data Acquisition Stations, one at Fairbanks in Alaska, and the other at Wallops Island in Virginia.

As we already know from his biography (*Spaceflight*, August 1970, p. 326) Gordon actually leads a double life because of his rival interest in balloons and airships. He first entered the space field by virtue of his interest in high altitude balloons and is still keen on the idea of promoting airships as energy savers.

Gordon's space interests lie very much with monitoring ground activities by satellite. GOES, for example, acts as a communications link by collecting data from land, sea and air. About 200 automatic platforms have been produced so far to provide the input. Gordon would like to see these expanded

Gordon Vaeth signs our Visitors Book.

still further and, especially, to cover the seismic and volcanic activity in the Pacific "ring of fire".

Another welcome visitor was Dr. Desmond King-Hele who arrived to do his stint on preparing another "Orbital Dynamics" issue of *JBIS*.

Desmond was the first scientist to be elected to Fellowship of the Royal Society for contributions to space research. His studies of the upper atmosphere and the Earth's gravity field, based on the analysis of satellite orbits, have continued ever since and now look set to become his Life's Work.

Desmond has been at the Royal Aircraft Establishment Space Department since its formation in 1962; he has been Deputy Chief Scientific Officer for the past 14 years.

He also dabbles in literary criticism and biography!

Arriving shortly afterwards was Charles Sheffield, past-President of the American Astronautical Society but born and bred in the UK until he emigrated to join the American space programme. His first space interests date back to 1963 when he was working on the USN geodetic satellite, the precursor to what is now known as GPS (Global Positioning Systems), before moving on to Lunar Orbiter at NASA Langley.

Currently Charles is Vice-President of the Earth Satellite

Charles Sheffield.

Corporation with a particular interest in satellite sensing systems and a special expertise in mineral, oil and gas exploration from Landsat images, besides crop forecasting from both meteorological satellites and Landsat.

The object of his current visit, apart from seeing us, was to discuss installing an image processing system at British Petroleum.

Writing-wise, Charles recently produced a colour book on Remote Sensing called "Earthwatch". This was originally a UK book, though subsequently published in other countries. He is now working on a sequel called "-Man on Earth" which is to appear early next year, and hopes to follow with another book shortly afterwards on space careers.

Science-fiction also figures large in his scheme of things. In 1979 he put out "The Web between the Worlds", almost simultaneously with Arthur Clarke's "The Fountains of Paradise". As it happened, both books featured space platforms. This must have been slightly embarrassing but, contrary to evil thoughts, there was no plagiarism, just sheer coincidence!

FAME AT LAST!

Send the Albert Memorial to the Moon? Go to the Sun with the London Fire Brigade as a cooling system? Surely these ideas are crazy enough to have appeared in *The Goons*?*

BBC radio recently repeated a selection of *The Goon* shows, made in the 1950's with the talents of Spike Milligan, Harry Secombe and Peter Sellers (he of "The Pink Panther" and "Being There"). In the repeat of 11 July, Professor Seagoon took his designs for a solar probe along to – yes, you're right – the offices of the British Interplanetary Society. The organisation that spawned the 1939 Moonship and the Daedalus interstellar probe was not impressed: the design was given the old thumbs down. Our Executive Secretary assures us that, despite the show, Bluebottle never did work for the BIS, although some might say that his influence is clearly present today.

On a more serious note, the mention does illustrate that the BIS – then still a very small organisation run largely on a voluntary basis – was known outside of space circles even before the first satellites began to catch the public's attention.

**We must explain to non-UK members that "The Goons" were a milestone in British comedy. Although some of the shows are more than a quarter of a century old they are still regarded with affection – even by people who weren't born at the time!*

OBITUARIES

With regret we record the deaths of Ernest Dove (Fellow), Arthur Bardens (Fellow) and Kenneth Miles (Fellow). Mr. Miles was, for many years, one of our most consistent attenders of meetings.

SOCIETY MEETINGS

SPACE COMMUNICATIONS MEETING

Communication via satellites has grown enormously during the 20 years since the experiments with Telstar in 1962. It was not until 1956 that the first Transatlantic Telephony cable (TAT 1) came into service; before that all telephone calls were made using high-frequency radio waves bounced off the ionosphere which, to put it mildly, did not always result in a satisfactory quality of service. Inter-continental or long international cables can give excellent quality but they have a number of disadvantages; for example, they have relatively narrow bandwidths (so they are not generally used for the TV transmissions), they can give direct connection only between two points (ie they are not suitable for multiple-access or broadcast transmissions) and they may be difficult or impossible to install and maintain on some routes (eg where there are high mountains between the points to be connected). However, satellites have none of these disadvantages.

We can now transmit live TV pictures across the world and the first Direct Broadcast Satellites - beaming directly into homes - will shortly be coming into service. This development and what it promises for the future were reviewed in a "Space Communications" Symposium organised by Ken Pike and held in the Society's Conference Room on 19 May. Papers were presented by representatives from, among others, the Independent Broadcasting Authority, Thames Television, Rediffusion, British Telecom International and British Aerospace.

The origin of the idea of using satellites in the 36,000 km-high equatorial orbit is usually traced back to the October 1945 issue of *Wireless World* in which Arthur C. Clarke pointed out that three satellites in such an orbit could provide world-wide communications. The advantage of using this orbit, of course, is that a satellite takes 24 hours to complete each revolution and thus appears to hang over a fixed point in the Earth's equator (ie, it is geostationary). If the orbit is inclined to the equator then the satellite appears to execute a "figure-of-8" in the sky.

When the space-age began with the launch of Sputnik 1 in October 1957 the opportunity for putting Clarke's proposal into practice was clear. One of the first uses of a satellite for communications came in December 1958 when the shell of an Atlas launcher was put into orbit and broadcast a taped Christmas message from President Eisenhower. Two-way communications arrived with the 100 ft diameter Echo balloon of 1960; radio signals could be bounced off its highly reflective surface but even with very high-power transmitters and sensitive receivers only a few communication-channels were available. What was required was an "active repeater" satellite in which the signal could be amplified and retransmitted. Telstar was launched in July 1962 and demonstrated the technique, *albeit* in a low orbit. Transmissions were made to and fro across the Atlantic, including live TV pictures. The next significant step was the launch, in 1963, of Syncom into geosynchronous orbit. Communication via synchronous satellite had arrived.

INTELSAT (International Telecommunications Satellite Organisation) was set up in 1964 to exploit this valuable resource; today there are 106 member nations. The first INTELSAT satellite (Early Bird or INTELSAT 1) was launched in 1965 and was capable of handling 240 telephone calls or TV, although only two ground stations could access it

Telstar demonstrated the techniques of using an "active repeater" satellite for communicating across large distances. This is Telstar 2 being mated to the third stage of its Delta launch vehicle in 1963.

NASA

at any one time. Each new type of INTELSAT satellite has made more effective use of the power and bandwidth available. INTELSAT I and II (and their antennae) were spun about their main axis to provide stability; this meant that much of their power was radiated into space. However, the INTELSAT III family, introduced in 1968, had a despun antenna platform (ie, it rotated in the opposite direction but at the same rate as the main body) so that most of the power from the satellite reached the Earth. INTELSAT IV (1971) carried additional large parabolic antennae that concentrated some of the power on busy regions, such as North America and Europe. INTELSAT V, now being introduced into service, has a very complex antenna system and uses (for the first time in INTELSAT) frequency bands at 14 and 11 GHz, as well as those at 6 and 4 GHz, to provide a capacity of about 12,000 telephony circuits plus two TV channels. INTELSAT VI, which should be in service around 1987, will be capable of dealing with 35,000 telephony circuits and four TV channels.

Although international satellite communications is now big business and traffic is still growing rapidly, it is now accepted as routine. However, public interest will undoubtedly be rekindled by the introduction of Direct Broadcast Satellites around the middle of this decade. These are satellites whose TV signals are powerful enough to be picked up by small domestic dish receivers. The concept has been tested to some extent already; for example, the NASA ATS 6 satellite was used after its launch in 1974 for beaming educational programmes to Indian villages. The Japanese BSE satellite was launched in November 1978 with two TV transponders, although it later failed.

It was recognised that the geostationary orbit was likely to become congested by TV satellites from nations all over the world, especially over the European area. The World Administrative Radio Council met in 1977 and allocated frequencies and orbital "slots" to nations; for example, the UK will use 31°W and Italy 19°W. Adjacent slots are 6° apart to prevent interference.

Generations of communications satellites apart: the Intelsat IVA (launched 1975–1978) compared with its Intelsat I ancestor (1965).

The greater parts of the problem now, though, are not technical but commercial, legal and political. Each nation's signals will spill over into other areas so there is immediately the problem of copyright and the temptation to transmit politically-angled material. The way the financial aspect is handled may determine the quality of service we get. TV distributed by satellite is already commonplace in the United States, although not on a DBS basis. Satellites such as Comstar, Westar and Satcom transmit programmes for reception by companies who then distribute them to subscribers via cables.

To explore the technical features of DBS in Europe, and to examine the possibilities of using small Earth stations for communications both in the 11/14 GHz and 20/30 GHz bands, the European Space Agency's L-Sat programme has been conceived, with a launch date in 1985. This satellite will carry multiple payloads to exploit the higher frequencies and to provide not only an experimental DBS for Italy, but also a steerable DBS Beam capable of illuminating individual countries as required.

The British Home Secretary announced this year that the UK will have two satellite channels by 1986 (although we have been allocated five), both to be run by the BBC. The present intention is to transmit popular repeats on one channel while the other, which will be available to subscribers only, will present material such as new feature films. But, as was pointed out at the symposium, there were only 39 such films produced last year and top quality drama costs £150,000 per hour. Even "talking heads" programmes cost about £12,000/hr. No doubt the format of the two channels will undergo significant changes before the service comes into operation.

SOVIET SPACE FORUM

The Society held its most successful Soviet Space Forum so far on 4 and 5 June. The opening session on the 4th saw the presentation of three papers under the chairmanship of Phillip Clark: "Reflection Characteristics of Certain Classes of Soviet Space Objects" by Paul Maley; "The Soviet Cosmonaut Team – Revisited" by Rex Hall; and "Visual Perceptions of Soviet Space Activities by Naive Eyewitness" by James Oberg (read by Paul Maley in the author's absence).

Saturday morning was given over to a showing of four films on Soviet topics: "Ten Years of Space Travel", "Stellar Town", "Baikonur Space Centre", and "Longer Roads to Space". The fourth dealt with the Soyuz 26 and 29 long-duration flights to Salyut 6, while the first was a repeat from last year but all agreed that it was interesting enough for a second showing.

Saturday afternoon saw a further three papers: "The Performance of the Onboard Timer of 1981-39A, Cosmos 1267", by Geoffrey Perry (read by Phillip Clark in the author's absence); "Kosmos Observations of the Falkland Conflict", by Ralph Gibbons; and "Aspects of the Soviet Union's Photoreconnaisance Satellite Programme", by Phillip Clark.

Soviet space planners always seem to come up with some exciting event around the time of BIS Soviet meetings. Just before the January 1980 forum the first Soyuz T flew to Salyut 6, and the June 1981 meeting was excited by the Kosmos 1267 "Star" module test. For 1982 it was expected that Salyut 7 would provide a talking point but late on the Friday evening a call from James Oberg in the US revealed that, on the day before, Kosmos 1374 had been launched and brought back to Earth. It subsequently appeared that this was an unmanned orbital test of the Soviet space shuttle.

A new feature of this years' meeting was a two-man "brains trust". Rex Hall and Phillip Clark set themselves up as guinea pigs to field questions from the floor, with everyone taking a lively part in the discussion.

Shuttle to the Moon?

Sir, In view of the many scientific advantages which would be gained from a manned return to the Moon in the near future, we have begun to wonder if the Space Shuttle could be used for this purpose. Is it possible, given suitable in-orbit refuelling, that the Space Shuttle Main Engines would be capable of taking the Shuttle to the Moon?

If this is possible, latterday LMs could be carried in the cargo bay, together with Spacelab modules and other necessary equipment. A detailed scientific study of the Moon could thus be made in the near future and at relatively low cost.

I. A. CRAWFORD
K. L. JOHNSON

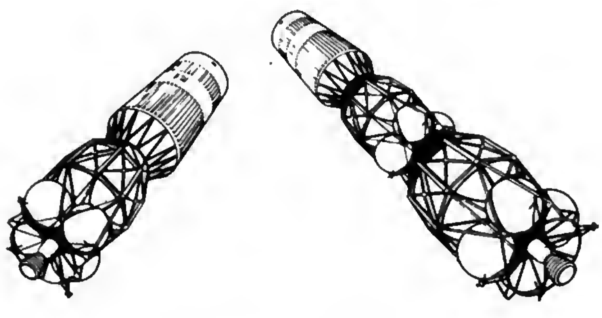
Dr. R. C. Parkinson replies:

The Space Shuttle is a very good way of getting into Earth orbit, but I'm afraid it is a very poor way of getting anywhere else.

For a start, you can't even refuel it in orbit. The main engines are supplied from the huge External Tank, which is jettisoned just before the Shuttle achieves its final orbital velocity. Thereafter it manoeuvres on small auxilliary engines. What is left is mostly mass for returning to Earth: the huge wings, the thermal insulation to withstand re-entry, hydraulics and landing gear and so forth. To take those beyond a low Earth orbit would be terribly wasteful of fuel.

Suppose that we hung on to the External Tank and refuelled that. Then we might be able to get the Shuttle into lunar orbit and back. But that tank takes 700 tons of propellant. The Shuttle payload is just under 30 tons. That means you would need something like 24 Shuttle flights to refuel the External Tank once. There must be better ways of doing it.

Even more problems come when you realise that the Shuttle could not carry either the Apollo Command Module or Lunar Module, not because of payload mass, but because of diameter. You need a new generation of "upper stages" tailored to the



Shuttle. What they will look like depends on how big a lunar programme you want. The cheapest way depends on whether you want to make half a dozen landings like Apollo or if you want to set up a thriving Lunar Colony.

The problem of returning to the Moon has been studied for the Shuttle era (e.g. *JBIS*, 34, p. 51, 1981). The principal requirement is the development of a high energy upper stage for the Shuttle. British Aerospace designed such a Space Tug in the early 1970's as a European contribution to the Shuttle programme. An alternative would be to adapt the Centaur stage for Shuttle use. These high energy stages would have wider use than simply returning to the Moon, but unfortunately they only become imperative in the context of manned missions beyond Earth orbit. At the moment NASA hasn't persuaded Congress to invest in one.

With such a high energy upper stage, carried within the Shuttle cargo bay, returning to the Moon would be a two-launch affair. The first Shuttle launch would use its upper stage to fire a lunar landing vehicle (probably a modified version of the same stage) into orbit round the Moon. The second Shuttle launch would lift a crew vehicle to rendezvous with the lunar landing vehicle in lunar orbit, and which would recover the crew after their mission on the Moon's surface and return them to Shuttle orbit round the Earth. You could use unmanned vehicles to deliver cargo packages to the Moon and set up a permanent exploration base. That is at about one tenth of the cost needed to send the Shuttle itself into lunar orbit.

Apollo, at 1970 prices, cost about $150 million per extra man placed on the Moon. Using a high energy stage carried by the Shuttle, a return to the Moon would cost about $17 million per man at 1980 prices. Most of that is possible because the Shuttle is so effective in delivering large payloads into low Earth orbit. If you set up a permanent base on the Moon with a plant to manufacture liquid oxygen as part of the propellant for the lunar landing vehicle you could halve this cost again. It is not really a matter of engineering any longer, it is a matter of the will to go.

Space Industrialisation

Sir, Over the last few years there has been considerable discussion about the industrialisation of space. Most of this has centred on technological concepts although some business interests have been active, for example a company that wants to buy a Space Shuttle [1]. It is felt that it is now timely to raise some business issues.

Firstly, we should define space industrialisation. If communications satellites are included, this occurred some time ago and is already a multi-billion dollar a year business. However, such satellites are generally disregarded and here I will confine the term to the production of goods or energy in space on a commercial basis. Although the age of space industrialisation is obviously not yet here there is much enthusiasm for the idea, especially amongst exponents of Space Colonies [2]. Without wanting to detract from these imaginative concepts, it is necessary to take a more business-like approach.

The true role of business is to meet customer needs whilst earning a sufficient return on all resources, time, capital, labour and materials, to ensure that the company can stay in business. Profit, a much misunderstood concept, is simply another cost to be met, the future cost of staying in business [3]. If space industrialisation is to be adopted, as with other innovation, certain conditions must be met. There must be a market for the products or services and there must be an adequate return on all resources; otherwise these are being wasted and should be shifted elsewhere.

If we examine the prospects for space industrialisation using these conditions we can illuminate areas for further study. Because of the high cost of space operations any space manufactured product must have an extremely high value per unit weight. We must look for such products in early studies. The most promising at present appear to be pharmaceutical compounds made by electrophoresis in the micro-gravity environment [4].

There are only likely to be a few products that fit this requirement and this highlights the fundamental barrier to space industrialisation launch costs. The US administration appears to favour the selling-off of the Space Transportation

System [5] to private operators. This is the right approach. NASA is an excellent engineering and scientific research and development organisation and should be left to develop engineering required by the aerospace industry and to do fundamental engineering and scientific research. However, any company or consortia contemplating investing in the Shuttle and associated systems must take a marketing approach and ask the market what it wants. The answer to this is almost certainly cheap, reliable boosters. This raises the question, was the Shuttle, the right product? If, as seems likely, the US military is the major customer, the answer is probably "yes" since their cost constraints are not serious and the Shuttle payload bay was designed around Department of Defense criteria.

However, another question concerns the suitability of the Shuttle in technical terms: is it too complex for market needs? I believe the answer is "yes" and that analysing the market needs up to, say, the year 2010 indicates that most non-military launches will be unmanned communications satellites or similar requiring only cheap, reliable boosters. In many ways the Shuttle, a technically brilliant machine, is ahead of its time. It also follows that Ariane is in an extremely good position whereas the Shuttle is to a certain extent a product without a market. If the innovation of space industrialisation is to be adopted the barrier of launch costs must be reduced. Then a whole range of products, mostly unimagined as yet, will become viable. Only then will traffic justify a Shuttle-type vehicle or a non-winged alternative [6]. Therefore the task of private, or public, enterprise must be to develop cheap, reliable boosters using appropriate levels of technology and based on market needs. Ariane is a good example and the various efforts of private companies should provide healthy competition in the future. The latter promise to be cheaper but as yet have uncertain levels of reliability.

The grand visions of space industrialisation will occur only if business can exploit the huge untapped resources of space to meet society's needs. This task, requiring both imagination and a business approach, will, I am sure, be undertaken and it now seems timely to begin a more serious appraisal of the possibilities.

STEVEN FAWKES
Stirling

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US Manned Mars Mission

Sir, In the memoirs *Witness to Power, the Nixon Years* of former White House counsel to President Nixon, John Ehrlichman, there is a glimpse into the national decision-making process that deeply affected the American space program throughout the 1970's and into the 1980's. Ehrlichman describes being called out of a meeting to be told that Vice- President Agnew's Space Advisory Committee was about to make some recommendations that were incompatible with the goals and objectives of the Nixon Administration. Efforts to disuade science advisor Lee DuBridge from agreeing with Agnew's committee on an endorsement of manned mission to Mars in 1981 had been unsuccessful. However popular a manned mission to Mars might have been with the people the budget could not be expanded to meet the recommendation.

Ehrlichman recounts his surprise at the obtuseness of Agnew when he explained the reasons why the Mars mission could not be undertaken. Ehrlichman then goes on to lament the wooing that NASA had aimed in the direction of the Vice-President. Ehrlichman, in exasperation, finally said that there was no money for such a mission and that the President did not want it in the Space Advisory Committee's recommendations. He also pointed out that it was Agnew's job to ensure that the President's wishes were carried out. Agnew's response was to demand a meeting with the President.

Within 15 minutes of Ehrlichman's departure of Agnew, he was on the 'phone explaining that the Mars mission was being moved from the list of "recommendations" to another category headed "Technical Feasible".

Such was the fate of the much-ballyhooed manned Mars mission.

GERALD BORROWMAN
Canada

Easy Come, Easy Go

Sir, Where *did* you get the story (p. 217, May 1982) that UNESCO is awarding $25 million to the "Arthur Clarke Communications Centre"? Would that it were true!

In fact, no award has been made, for the simple reason that the experts advising on the scheme left only last week, (this was in July – Ed.), and no action can be taken until they have submitted their report. Even if the response is favourable, the amounts likely to be involved are only a tiny fraction of the figure quoted.

The situation at the moment is that the Government is providing land and buildings, adjacent to the University, and I am donating $25,000 of the Marconi Award to help in the initial stages. We hope that during the next few years additional help will come from UNESCO, individual countries and foundations.

I hope that you will publish this correction to your report – which may have the unfortunate effect of discouraging other donors!

ARTHUR C. CLARKE
Chancellor, University of Moratuwa,
Sri Lanka

Might-Have-Been Spaceships

Sir, The letter from Len Carter on fantasy spaceships (last month's correspondence) opens up whole new vistas. Some members may still recall the "Britain Can Make It" exhibition on London's South Bank shortly after the war. This was intended to provide a magnificent shot in the arm for a war-weary populace and to show that, even after two world wars, the country was still ready for anything. In fairness, the exhibition was very good indeed.

The only thing which marred the proceedings was a so-called spaceship, designed by Warnett Kennedy and which received substantial publicity at the time. In fact, Mr. Kennedy was an artistic designer, pure and simple, who had taken no steps whatever to find out about spaceships. His result was a ball-shaped cellular structure with no discernible means of propulsion, habitation or storage, unrealistic and incomprehensible to anyone with the slightest knowledge of the subject.

The Editor is always interested in receiving items of correspondence, notes, comments, or reviews for possible publication. Items submitted must be kept brief, owing to the limitations of space in our magazine. The Editor reserves the right to shorten or otherwise adapt material to fit, for this reason.

In fact, when asked *why* it was shaped like a ball, his only answer was that "it looked more perfect that way!"

Some years later, in the late 1950's-early 1960's as far as I recall, the Ideal Home Exhibition, which then attracted packed audiences, also hit on the idea of a spaceship, and with the prerequisite (apparently standard practice) that someone else should pay for it. Bristol-Siddeley duly obliged, no doubt due to their successful flights with Black Knight.

What eventually emerged at Olympia, and what the packed customers made of it, is a matter of some conjecture. Perhaps other members can throw some light upon it?

A. NON

Clarke, Tsiolkovski or Who?

Sir, I have noted the increasing use of the term "Clarke orbit" for geosynchronous orbit. May I point out a possible need for a correction?

In the Kenneth Syers translation of "Beyond the Planet Earth" by Konstantin Tsiolkovski, published by Pergamon Press, in 1960, the second paragraph of chapter 17 begins as follows:

On the scientists' advice, this swarm of rocket ships was halted at a distance of 5½ Earth Radii, or 33,000 kilometres, from the surface. The time it took to make one complete circuit of the planet corresponded exactly to a terrestrial twenty-four hour day. Daytime was practically continuous, alternating every twenty-four hours with brief solar eclipses which bore no resemblance to night . . .

According to the Introduction, the novel was begun in 1896, the first half was published in 1916 and the rest in 1920. The same passage appears in the translation by V. Talmy included in "The Call of the Cosmos", a collection of Tsiolkovski's works published soon after 1960 by the Foreign Languages Publishing House, Moscow, although Talmy divides the book into shorter chapters and this section is now chapter 40.

On the face of it, should we not, for accuracy, refer to "Clarke satellites in Tsiolkovski orbit?"

DUNCAN LUNAN
Ayrshire

Arthur Clarke replies:

I welcome the support in my (apparently losing) battle to stop people naming things after me. The IAU has the right idea; you have to be safely dead before you can be immortalised on the Moon or planets (though exceptions have been made for astronauts and cosmonauts).

However, I cannot quite agree with the rest of his letter. Tsiolkovski got the idea of a stationary satellite even earlier than the reference he mentions. In my IAF address "The Space Elevator: 'Thought Experiment' or Key to the Universe?" (*Adv. Earth Oriented Appl. Space Tech.* Vol 1, pp. 39–48) I quote a passage from the 1895 paper "Day-Dreams of Heaven and Earth", which contains what is essentially the geosynchronous concept.

Nevertheless, I don't consider that this justifies labelling it with Tsiolkovski's name. In the first place, the idea of a 24 hour satellite is so trivial that it would have been obvious to any astronomer from the time of Kepler onwards. I don't know when it first appeared in print (when the moons of Mars were discovered?) and suggest this as an interesting research project.

Secondly, if every idea that Tsiolkovski mentioned had his name attached to it, there's very little in the whole field of astronautics that would be excluded!

A much better case could be made for the man who first worked out detailed engineering plans for a space station – and then placed it in synchronous orbit. I refer, of course, to the Austrian Captain Potočnik whose book, *Das Problem der Befahrung des Weltraums*, was published under the name Hermann Noordung in 1928. Though I have never seen Potočnik's book, I knew of its basic ideas and it is the only astronautical reference in both my *Wireless World* paper and the earlier (25 May 1945) BIS memorandum.

Even the proposed name "Clarke satellite" for a space relay could be challenged; in various forms, the idea was fairly common in the science fiction of the 1930–45 period. (See especially George O. Smith's "Venus Equilateral" series.) What I did was to take two already existing elements, combine them synergistically, and point out the implications of the result.

Incidentally, I consider the lunar launcher ("Electromagnetic Launching as a Major Contribution to Spaceflight", *JBIS*, IX, 6 November 1950) a much more original idea, since to the best of my knowledge there are no precedents (though of course the idea of an *Earth*-based launcher is an old one.) In the long run it may be even more important than the communications satellite.

However, nomenclature is decided not by logic or justice but by accident and convenience. History will settle these matters, as it always does.

Terraforming Venus

Sir, I read with interest Saul Adelman's article "Terraforming Venus" in last February's *Spaceflight*. There were a number of rather fundamental issues not addressed in the paper. For example, how long would it take for the massively disrupted surface of the planet to stabilise to the point at which any form of human colonisation at all might be contemplated? Also, how might the present atmosphere be converted to one broadly similar to that of the Earth, and how long would this take? We probably won't have answers to such questions for decades.

What I would like to question is the need for technologies so far in advance of what we are presently able to conceive. By the time humanity (or its descendants) is able to harness energies, and quantities of antimatter of the order of those referred to, the Solar System is likely to be so populated as to preclude feats of engineering potentially so disruptive.

I believe the task could be accomplished by the use of technology and financial resources relevant to a society able to construct a "Daedalus"-type star probe rather than one far more advanced than that. Here is a very brief outline of the main points of a possible scheme:

1. The amount of water and other volatiles on Venus would need to be raised to levels similar to those of the Earth. This would include an allowance for water which would combine chemically with cooled Venusian rocks, e.g. as water of crystallisation, as well as allowing for water to go into oceans. We are talking about quantities of water far in excess of what could be accumulated by gathering up hundreds of comets. Rather, we are talking about committing one or more mid-sized outer planetary moons to the task.

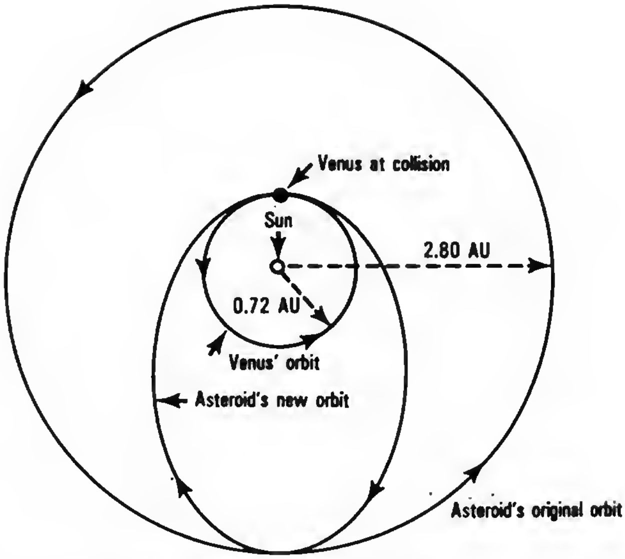
2. The two Saturnian moons Iapetus and Rhea would, between them, have quantities of water of the right order.

3. These moons could, in theory, be placed into appropriate transfer orbits to approach Venus by means of massive thermo-nuclear explosive devices, probably many dozens for each moon, each having over a million tonnes of deuterium. Rather than placing these devices directly on the orbitally trailing side surface of each moon, with the risk of adding to the amount of large chunks of matter in highly eccentric orbits in the Solar System, it might be better to use a few devices to raise a few trillion tonnes of surface material above the moon's surface, then detonate many more to vaporise and ionise this material to generate high velocity reaction mass.

4. By deeply burying a huge (hundreds of kilometres in diameter) superconducting coil under the surface of each moon to encircle the major detonation site, then building the magnetic field to a strength of a few Tesla (no mean feat!) the reaction mass could be directed away from the moon more effectively.
5. These two moons, if brought into grazing collision with the surface of Venus, would yield a system having a total angular momentum not dissimilar to that of the planet having a more or less terrestrial-length day.
6. By the time they would be needed, micro-organisms able to fix the carbon dioxide in the Venusian atmosphere should be available, so clearing the way for the conversion of the atmosphere to one terrestrial in nature.

Admittedly, this scheme sounds almost as far-fetched as that proposed by Saul Adelman, but at least it does not require the use of millions of tonnes of antimatter, or of engines able to utilise energies of the scale he refers to. This is important, for unless Venus is terraformed (or at least a start made) before the end of the twenty-second century, it probably never will be. Already I can hear the howls of outrage perpetrated by members of the Solar System Wilderness Society in the year 2150 when the scheme is first tabled for serious consideration!

RICHARD J. HUNWICK,
New South Wales,
Australia



The scenario for terraforming Venus as discussed by Saul Adelman in February's *Spaceflight*.

Dr. Adelman replies:

Mr. Hunwick raises some important issues. The purpose of my article was to show that it is now possible to consider terraforming Venus based on technologies which we can foresee and to develop a "rapid mode" scenario, based on order of magnitude estimates. Historically, even large scale engineering projects tend to take decades rather than centuries.

I advocate the study of terraforming planets as a useful engineering and scientific exercise. The new societies which will result on Terraformed Venus and on Terraformed Mars should be extremely beneficial for the advancement of our civilization. Terraformed worlds or any form of space colonization, on the other hand, cannot be cost effective means to relieve population pressures.

My calculations assumed that angular momentum would be conserved and instantaneously be redistributed at the moment of collision. If in the crust zones of latitude were liquified, for example, then these outer layers of the planet might be rotationally decoupled from the interior and the remaining polar caps. As the liquified zones cooled, turbulence could operate to prevent angular momentum from being conserved. Thus Venus might not be spun-up as much as I calculated. If more exact calculations show this likely for collisions with objects as large as I proposed, then one could speed up the rotation rate by either putting an asteroid into a close Venusian orbit, a scheme which would probably take thousands of years to produce a substantial result, or using many smaller asteroids or asteroidal fragments. In any event one would not want to substantially disturb more than 25 per cent of the surface area so that relatively soon after the asteroidal collisions the undisturbed part of the surface could be explored by men. I believe my rapid mode scenario meets this requirement.

A problem with causing icy bodies to collide with Venus is that if the relative velocity is large, which is a necessity to speed up the planet, then the temperature of the icy body will likely to be increased to the point where most of the molecules would be dissociated. Thus instead of water, oxygen and hydrogen gas would probably be produced.

Mr. Benkovitch has suggested (*JBIS*, July 1982, p. 325) that the asteroidal orbit changes utilize the gravitational assist of Jupiter. This reduces the energy required to about 5 per cent of what I initially proposed. If the orbital calculations show that reasonable windows exist for such manoeuvres, then the process of terraforming Venus could start with advanced fusion instead of antimatter technology. Still, the process of terraforming Venus is more intrinsically difficult than that of Mars and is likely to be undertaken after experience is gained with Mars.

The use of micro-organisms to convert the atmosphere of Venus to a terrestrial one is likely to be a very long-term process if one works with the whole atmosphere. The collisions of solid bodies, such as the two large asteroids with Venus, are very efficient mechanisms to remove the atmosphere. Then one can use cometary nuclei and other icy bodies to create a new atmosphere with the desired composition. There are severe limits to the percentage of carbon dioxide in the air we breathe. It will be easier to work with a relatively thin remnant atmosphere composed mostly of carbon dioxide than with the current massive atmosphere of Venus.

Salyut 6 Cosmonauts

Sir, In an article in the August 1981 issue of *Aviatsiya I Kosmonavtika* entitled "The Extended Life of Salyut 6" Gherman Titov states that "the original plans for operations on board Salyut 6 envisaged only three basic expeditions"[1]. Given this information, I believe it is possible to reconstruct the crew assignments for the three long-duration missions originally planned for Salyut 6:

Prime crew	Reserve crew
Kovalyonok Ryumin	Romanenko Ivanchenkov
Romanenko Ivanchenkov	Lyakhov Lebedev
Lyakhov Lebedev	Popov Strekalov

I am adhering to the pattern observed during the successful long-duration missions to Salyut 6 of the reserve crew advancing to prime status on the subsequent "basic expedition". The

assignments for the first expedition have been documented [2], but those of the second and third are somewhat more speculative. Teaming Lyakhov with Lebedev is the product of supposition from the actual crew assignments, as outlined below. There is precedence for a Popov-Strekalov crew, since they served as reserves to Bykovsky and Aksyonov on Soyuz 22 [3].

The crew assignments were disrupted by the Soyuz 25 docking failure, possibly leading to the following scenario. Grechko, due to his familiarity with the station's docking mechanism, replaced Ivanchenkov as Romanenko's flight engineer in order to assess any damage as a result of the Soyuz 25 docking attempts [2]. Ivanchenkov was joined by Kovalyonok to form the Soyuz 26 reserve crew [4]. Dzhanibekov and Makarov then flew aboard Soyuz 27 to provide the long-duration crew with a fresh spacecraft for their return flight. As Kovalyonok and Ivanchenkov were again the reserves for Soyuz 27 [4], it would appear that the Soyuz 27 crew were not involved in training for long-duration missions. They had probably been summoned out of the Soyuz T development programme specifically for this flight. Makarov's appearance on the Soyuz T-3 mission would seem to bear this out. Kovalyonok and Ivanchenkov then moved on to fly Soyuz 29, with Lyakhov and Ryumin as the reserve crew [5]. Ryumin's preferential assignment to the third basic expedition crew (Soyuz 32) therefore moved Lebedev to reserve status for that mission with Popov. As a result of this, Strekalov was probably removed from training for a long-duration flight to Salyut 6. He was then free to begin training for flights aboard the improved Soyuz T spacecraft, subsequently serving as cosmonaut researcher on Soyuz T-3. The unexpected longevity of the station provided the opportunity for two additional basic expeditions to be flown.

An additional implication of the above scheme, if Lyakhov was indeed a reserve commander for a Salyut 4 mission [4], is that Lyakhov and Lebedev may have served as the Soyuz 17 reserve crew.

JOHN HAMMERLAND,
Lakewood, Colorado

REFERENCES

1. *USSR Report-Space*, NO. 15, Foreign Broadcast Information Service, 29 March 1982, p. 12.
2. James E. Oberg, *Red Star In Orbit*, pp. 163-164, 204.
3. Gordon R. Hooper, "The Cosmonauts-Part 22," *Spaceflight*, January 1982, pp. 30-31.
4. James E. Oberg, "Correspondence," *Spaceflight*, January 1980, p. 48.
5. Neville Kidger, "Salyut 6 Mission Report," *Spaceflight*, February 1980, p. 52.

Local History

Sir, Many readers may not be aware of plans to redevelop Vauxhall Cross, the area in which the Society's HQ building is situated. A number of plans are currently being considered, all involving massive high-rise tower blocks which will alter the character of the area completely.

This makes it all the more necessary for the Society to forge links with the past. It is extremely important that the Society do this. The area where the Society has its building was, in former times, almost the hub of London, visited by Royalty and commoners alike. Vauxhall Gardens, a few hundred yards away from our present site, witnessed not only the first parachute descent in the world but also the first manned ascent by balloon in England!

In the 18th and 19th centuries, the area was dominated by artisans skilled in many crafts, not least by Potters in a multitude of small pottery works, culminating eventually into the massive Doulton complex, whose wares are now eagerly sought by museum and collector alike.

While rooting around the other day, we discovered this remnant of the old Dalton factory building, incorporated in the side of a more modern block but easily distinguishable by its outstanding semi-Gothic design (with mock Elizabethan chimney pots) and lavish use of tiling to decorate the walls.

The front entrance also has a sculptured frieze, typical of George Tinworth's work, though, at the time of going to press, we have made no attempt to authenticate this.

Links with the past were even shown when the Society dug up its front doorstep! The old clay pipes which came to light set up a lively correspondence in *Spaceflight*[1].

But the connection is even more direct than that. For example, the genius who probably contributed most to the world-wide fame of Doulton Pottery was undoubtedly George Tinworth. He attracted the notice of Queen Victoria herself. Now, George Tinworth features in the local history archives of Southwark. He was born in Walworth, less than half a mile from where our own Executive Secretary was born! They undoubtedly knew the same buildings, scenes and might even have known some of the same people. Not only is there a large file on George Tinworth in the local history records but, surprisingly, one has been started for Len Carter's activities, too, though his is currently very slim indeed as he tends to hide his light under many a bushel!

M. W. WHOLEY
Midhurst, Sussex

REFERENCE

1. "Correspondence", *Spaceflight*, January 1979, p.44.

The Society would, indeed, like to own a piece of sculpture or pottery fashioned by George Tinworth but we understand that an item of modest proportions, even if available, would cost around £400-£500. Len Carter, who has currently written a book about the district in which he was born (though no-one will publish it!) says that he mentions George Tinworth in his text — Ed.

Next Month: December's issue of *Spaceflight* will feature articles on the Space Telescope and the dangers of space debris.

Local History

Sir, Regarding recent correspondence on the history of the area around the BIS HQ, I remember an occasion in December 1980, while trying to work out that "subway" means something different in America and Britain, when I came across a group excavating in what I supposed was a bombed-out dock area by the side of Vauxhall Bridge.

It turned out they were members of a local archaeological society excavating the ruins of a 19th century pottery factory, only a few hundred yards from the BIS offices. The wife of one of the team even turned out to be a BIS member!

The fact that such groups and the BIS are interested in the local technological archaeology of Lambeth is worthy of praise and support.

MITCHELL SHARPE
Huntsville, Alabama

Leading Questions

Sir, One ought to expand recent references to Society publicity by pointing out that there can be hidden hazards in dealing with the media.

As an example, one may be put in the position of having to answer a "Have you stopped beating your wife?" question. A classic example of this took place years ago when a newspaper reporter wished to interview a lady Member of the Society. He was put on to Sheila Mather, then prepared to wave the BIS flag. The first question put to her was, "Will you take your iron into Space?". Surprised, if not completely bewildered, Sheila muttered "No", thinking that the reporter had taken leave of his senses.

Not a bit of it. A headline duly appeared "Sheila won't take her iron into space" which really made the whole interview look utterly ridiculous.

In all of its long history, however, few reporters have been deliberately unkind to the Society though there was one event, which still raises a smile, that took place when Members held a meeting just after the end of the war. No projection facilities worth the name were then available, so an elderly epidiascope was found and pressed into use. Unfortunately, the number of people attending was so great that the epidiascope had to be pushed further and further back, with the result that the pictures projected became dimmer and dimmer. Eager to leap on a ready-made waggon, one newspaper commentator immediately reported "Here is a group of people who want to project a vehicle to the Moon, yet they can't project a picture on a screen!"

One may still come up against the pre-war comment from William Hickey in the "Daily Express" where, disparaging the idea of lunar flight, he dispenses the immortal advice that "Members of the Society should rather devote their energies to making it a better world for the Moon to revolve round" - as though one excluded the other!

The Society, as far as I am aware, met with only one occasion when a reporter was deliberately ill-mannered. This took place when the Society was hosting the second IAF (London) Congress. Press coverage was excellent and extensive; the press facilities were first class. However, during the proceedings, representatives from some of the Societies decided to meet in a committee room to hack out an IAF Constitution. A reporter from the *Yorkshire Post* demanded admittance. When told that the committee members, engaged in a boring task, and wanting to be left to get on with it, the reporter turned livid. Out of all the extensive and favourable coverage received, the only sour note duly appeared in the *Yorkshire Post*, containing a snarling complaint that representatives, meeting behind closed doors, clearly had something to hide!

L. J. CARTER
BIS

SNIPPETS

Computing

Sir, I would like to take this opportunity to confirm that I've been able to assist Mr. D. J. Russel (presently in Hong Kong) and A. J. Eldridge (Surrey) who sought advice on computer simulations, Moon landings, etc.

After the brush-offs I received from several sources when I was hunting for star-data, the prompt and courteous assistance from the BIS left a deep impression.

N. KELLY
Liverpool

Woomera

Sir, When I was in Woomera I saw that they had an open-air "museum". This included a collection of full-size dummy rockets and missiles fired from Woomera. It was by no means complete but included Black Arrow, Black Knight, Skylark and Long Tom rockets, together with Bloodhound, Thunderbird, Sea Slug, Rapier, Blue Steel and Ikara missiles. There were also Jindivik and Gloster Meteor drones.

R. GREAVES

An Offer We Can't Refuse

Sir, You would be a fool not to listen. I have just made the technological breakthrough of the century. All you have to do is acknowledge the work I have sent you.

(Name and address omitted)

Keep Up The Good Work

Sir, Since joining the Society recently, I've been impressed by the work being done to promote space development around the world. I've found that Spaceflight covers current space affairs very well indeed and I always enjoy reading the magazine.

L. B. HANDS
Northampton

Heroes

Sir, Is it too much to hope that one day British astronauts will replace over-exploited, lipstick-daubed, raucous-voiced pop singers, as the idol of British youth? I, for one, prefer my heroes to behave like men.

J. BATES
Cleveland

Ouch!

Sir, As soon as I come up with the articles for the magazine [Mr. Sharp is editor of our Astronautics History JBIS - Ed.] I will send them to the divine Shirley, who as I understand worked herself into an early grave for a set of cheap crockery and a tea pot.

MITCHELL SHARPE
Alabama

All becomes clear with a quick glance at p. 279 of the October 1981 Spaceflight - Ed.

BIS Mention

Sir, While reading the book "Enterprise", by Jerry Grey, I notice that several mentions are made of our Society.

DAVE SHAYLER
W. Midlands

When You've Got to Go ...

Sir, I am sorry that I am moving back to Sweden because I have very much enjoyed the Society's lectures and film shows.

CHRISTIAN TAENG
Harrow, Middx

SPACEFLIGHT

Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 27/29 South Lambeth Road, London SW8 1SZ Tel: 01-735 3160

Correspondence and manuscripts intended for publication should be addressed to the Editor, 27/29 South Lambeth Road, London SW8 1SZ.

Opinions in signed articles are those of contributors and do not necessarily reflect the views of the Editor or the Council of the British Interplanetary Society, unless such is expressly stated to be the case.

ASTRONOMICAL STUDY COURSE

During its 50th Anniversary Year, the Society will embark on its most ambitious Study Course yet. Called "Update your Astronomy", the Course, organised in collaboration with Astronomers at the Royal Greenwich Observatory, will provide an opportunity for members to learn of the many new and exciting developments in astronomy in recent years.

Because of the number of lectures, the course will extend over two sessions with a reduced fee (£10) where Registration is made for the combined course at the same time. The fee for each of the two sessions is £6, if paid singly. Registration Forms are available from the Executive Secretary.

The topics and the speakers are listed in the Notices below as fully as space permits, in chronological order: 12 October, 24 November, 1 December, 5 January 1983, 2 February 1983, 2 March 1983, 30 March 1983, 6 April 1983, 14 April 1983. More will be added as arranged.

Study Course – Change of Date

Title: **UPDATING QUASARS**
by Dr. R. Carswell
Observatorio Interamericarno De Cerro Tololo

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **12 October 1982**, 7.00–9.00 p.m.

Please note the change of date of this lecture.

For details on joining the "Update Your Astronomy" Study Course, see the note at the beginning of this month's Notices. Since all of our speakers are working astronomers, it may be necessary occasionally to change the sequence of lectures.

First Night

An opportunity for new members of the Society (and interested guests) to meet Members of the Council and Officers of the Society will occur on **13 October 1982**, at the Society's HQ Building, 27/29 South Lambeth Road, London, SW8 1SZ, 7.00-9.00 p.m.

Our first two meetings have proved so popular that a third informal evening has been arranged when members can hear about the History and Activities of the Society, see a space film and have an opportunity for a short guided tour of the Building.

New members, or those who have not previously attended any Society function, who would like to attend are invited to apply in good time, enclosing a reply-paid envelope.

Late Cancellation

Please note that the lecture "Social and Psychological Aspects of Long Duration Space Flight" by Prof. B. J. Bluth, Advertised for 18 October, has been cancelled as the speaker is unable to attend.

Space Systems Conference

Theme: **THE SPACE TRANSPORTATION SYSTEM**
A Review of its Present Capability and Evolution

A three-day meeting to be held in Washington, D.C. USA on **18–20 October 1982**, sponsored by the AIAA, AAS, NSC, DGLR, JAS and cosponsored by the BIS.

Subject areas to be covered include:

(a) The Space Shuttle Orbiter
(b) Orbital Transfer Vehicles
(c) Reusable vs. Expendable Launch Vehicles
(d) Man's Role in Ground and Flight Operations
(e) User Needs for a Space Truck
(f) The Orbital Facility Applications

Intending registrants should write direct to: Mrs. C. D. Trudell, Mail Station 14-1, McDonnell Douglas Astronautics Company, 5301 Bolsa Avenue, Huntington Beach, California 92647, USA.

Film Show

Theme: **STEPS TO THE MOON – 2**

The second programme in this series will be screened at a meeting to be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **27 October 1982**, 7.00-8.30 p.m.

The programme will include the following:

(a) Assignment Shoot the Moon
(b) Apollo/Saturn V Lunar Mission
(c) Debrief Apollo 8
(d) Apollo 9 – The Duet of Spider and Cumdrop
(e) Apollo 10: Green Light for a Lunar Landing

Admission is by ticket only. Members wishing to attend should apply in good time, to the executive secretary enclosing a reply paid envelope.

LIBRARY

The Library will be open to members from 5.30-7.00 p.m. on each of the following dates:

20 Oct. 1982

27 Oct. 1982	17 Nov. 1982
24 Nov. 1982	1 Dec. 1982
8 Dec. 1982	5 Jan. 1983
26 Jan. 1983	2 Feb. 1983
16 Feb. 1983	2 Mar. 1983

While every effort will be made to adhere to the published programme, the Society cannot be held responsible for any changes made necessary for reasons outside its control.

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SPACEFLIGHT

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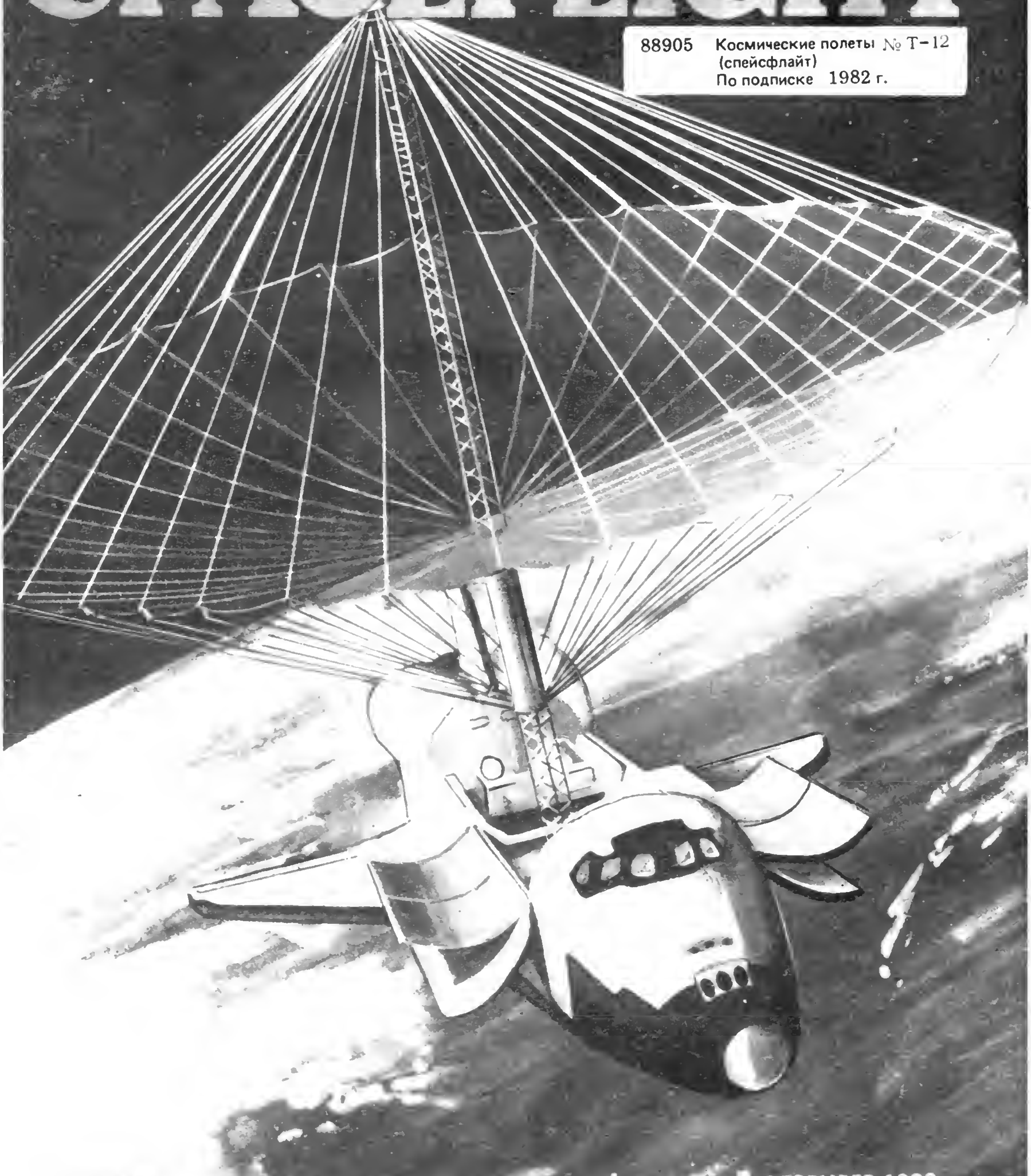

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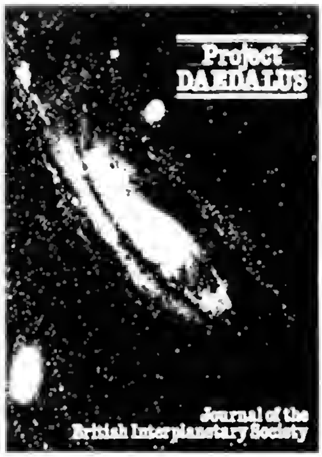
DECEMBER 1982
VOLUME 24 No. 12

IMPORTANT SOCIETY PUBLICATIONS

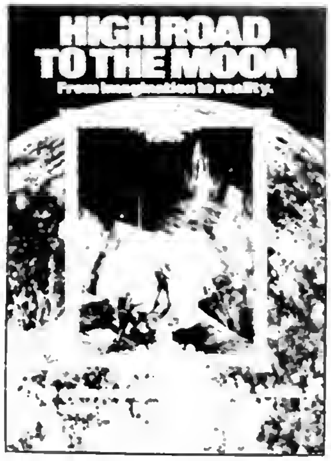
The Society's *Daedalus* study has rightly received worldwide acclaim for its forward-looking thinking. The Report has proved so popular that a second impression is now available.

It contains 24 papers which summarise the work of the four year study for a Starship Probe to Barnard's Star, organised by Dr. A. R. Martin and Alan Bond. It runs to 192 pp. The cost is £7.00 ($16.00).



Front cover of 192 pp Daedalus Final Report, published in 1978 and now available again with a 2nd impression in 1981.

High Road to the Moon, by Dr. Bob Parkinson, records many of the Society's original ideas and discussions on Lunar exploration in the visionary drawings by the late R. A. Smith. These pictures depict ideas on orbital rockets, space probes, ships to take men to the Moon and beyond. The book contains 120 pages and about 150 illustrations and text. It is available for £6.00 ($15.00) post free.



Front cover of the 120 pp *High Road to the Moon.*

SPACEFLIGHT

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Editor:
G. V. Groves

Managing Editor:
A. Wilson

Assistant Editors:
L. J. Carter
A. D. Farmer

CONTENTS

434 **Space Telescope: Eye on the Universe** *Dr. J. K. Davies*

442 **Space at JPL** *Dr. W. I. McLaughlin*

446 **The Crowded Sky** *Nicholas L. Johnson*

450 **Space Report**

457 **The Decline and Fall of SETI** *Robert Sheaffer*

459 **Space Communications**

460 **The Maiden Voyage of "Columbia": Part 3** *John A. Pfannerstill*

466 **Publications Potpourri**

469 **Satellite Digest - 159** *Robert D. Christy*

472 **INSAT-1: India's Dual Spacecraft** *Nicholas Steggall*

473 **Society News**

474 **Book Notices**

475 **Correspondence**

COVER

Radio astronomy from orbit. In this artist's concept, a prototype of an antenna to be used in a radio astronomy system known as a Very Long Baseline Interferometer is tested aboard the Space Shuttle. Such an experiment has been proposed for the late 1980's with a permanent operational system in orbit by the late 1990's.

NASA

MILESTONES

August 1982

16 A rocket motor of the type to be used to boost the communication satellites carried on the fifth Shuttle flight in November fails during a ground test. Engineers will carry out further tests to see if the flight will be affected.

27 The Soyuz T-7 crew, including female cosmonaut Svetlana Savitskaya, return to Earth in the Soyuz T-5 craft after a week aboard the Salyut 7 space station.

27 Launch of the Anik D1 communications satellite marks the first use of the Delta 3920/Payload Assist Module vehicle. NASA has had to re-activate the 17B launch facility at the Cape to cope with the launch rate expected.

September 1982

2 The first of Shuttle Orbiter *Challenger's* main engines is test fired for 1½ seconds to begin the qualification programme which must be completed before the three SSMEs can be installed in the vehicle. This ignition test will be followed by a 100 second calibration firing and, finally, a 500 second endurance test. The engines will reach thrust levels of 109% of normal; *Challenger* will be able to carry heavier payloads than *Columbia*.

9 Space Services, Inc. launches its Conestoga 1 rocket (see *Spaceflight*, March 1982, p.133) to a height of 195 mi (314 km). The 46,500 lbf (207 kN) thrust Minuteman 1 second stage will be used as part of an orbital rocket to be tested next year, with a commercial flight in 1984. Mission director was Deke Slayton, ex-NASA astronaut.

9 Shuttle Orbiter *Columbia* is moved from its processing facility to the Vehicle Assembly Building for mating with the External Tank and boosters for STS-5. *Columbia* spent only 41 days in its "hangar". Officials are now worried that *Challenger's* debut flight, planned for 20 January, may be delayed because of late delivery of the main engines.

9 A Chinese satellite is launched into a 393 × 172 km, 63 deg. orbit by the space launcher version of the CSS-X-4 ICBM. Apparently on a reconnaissance mission, the satellite is reported to be recovered five days later.

10 Launch of the fifth Ariane rockett, carrying Marecs B and Sirio 2 satellites, ends in failure after problems with the third-stage. The lower stages performed well but 560 seconds after launch, approximately half way through the 10-minute third stage burn, the turbine speed began to drop and engine pressure fell from 32 atmospheres to zero. This was the first of the "promotional series" of flights after the first four test launches, the second of which failed in May 1980. Subsequent flights may now be delayed (see *Spaceflight*, November 1982, p.402).

11 It is reported that two Indian pilots will be chosen this month for cosmonaut training, beginning before the end of October. Also, Academician Oleg Gazenko has implied that more women cosmonauts will fly.

20 It is reported that NASA will not take Shuttle Orbiter *Columbia* out of service for modifications after the STS-5 mission because of launch schedule pressure. It may have to wait until Orbiter *Discovery* is delivered in late 1983.

20 West German Ulf Merbold and American Byron Lichtenberg are named as the Spacelab 1 Payload Specialists for the September 1983 mission. They will fly with pilots John Young and Brewster Shaw, and Mission Specialists Owen Garriott and Robert Parker. Wubbo Ockels (Holland) and Michael Lampton (US) will act as backups. It has been reported that a seventh crew member might be added, and the flight delayed, because of the workload now expected.

SPACE TELESCOPE: EYE ON THE UNIVERSE

By Dr. J. K. Davies

Introduction

Ever since Galileo Galilei first turned his telescope on the heavens in 1609, astronomers have constantly sought to improve the power of their instruments. At first progress was slow since development proceeded on a largely trial and error basis and most Renaissance astronomers built their own telescopes. Those best able to grind lenses soon gained reputations as great observers.

Galileo's first "optik tube" was a refracting telescope, as were all early astronomical instruments. Some 50 years passed before Isaac Newton demonstrated the first practical reflecting telescope. Since then, astronomical telescopes have grown steadily in size, complexity and optical performance. This development is detailed in many reference books, e.g. Ref. 1.

The main lens or mirror of a telescope is known as the primary and, in theory, the ability to see fine detail increases with its diameter. Consequently, it would seem that to obtain better and better views of the Universe it should simply be necessary to build bigger telescopes. Indeed, telescopes have grown from the tiny lens of Galileo's optik tube to the 200 inch (508 cm) reflecting telescope at Mt. Palomar, commissioned in 1948. More recently, an even larger telescope, with a 230 inch (6 m) main mirror, has been built in the USSR, but to date its performance has not come fully up to expectations.

Unfortunately, the theoretical resolving power of a large telescope is much higher than the best resolution achievable in practice. This is because no matter how well a telescope is made it cannot avoid looking through the turbulent blanket of the atmosphere. Most of the radiation reaching the Earth from space is absorbed by the atmosphere, and that which does penetrate to the ground is distorted by its passage through the air. This distortion is apparent in the familiar twinkling of stars known to us all from nursery rhymes.

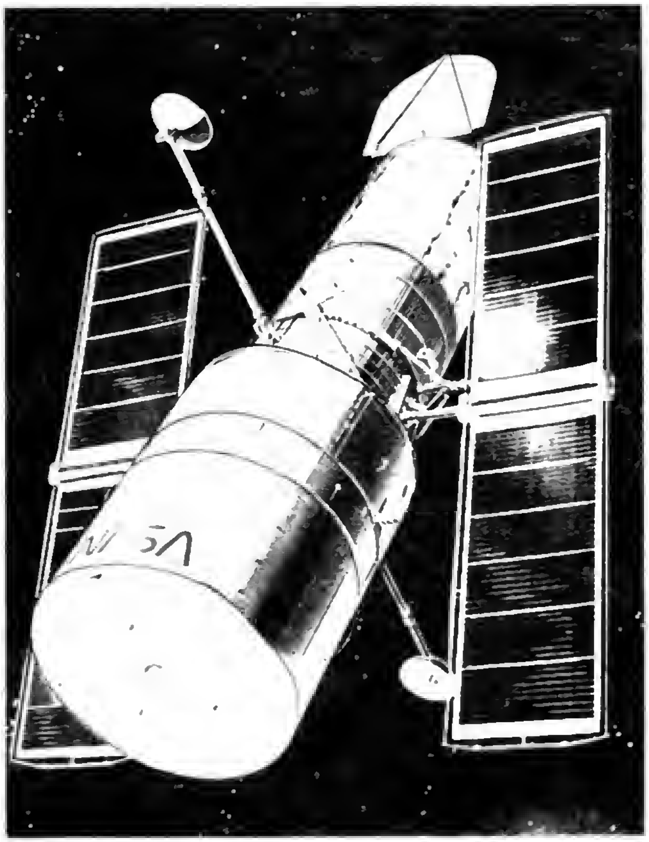
In an attempt to reduce atmospheric interference, most large telescopes are placed on high mountains where they will get the best possible viewing conditions, away from industrial pollution and with much of the atmospheric blanket below them. Even so, atmospheric distortion will always prevent large telescopes achieving their theoretical resolving power and, because of this, the Earth's largest telescopes are used to study very faint objects, too dim to be glimpsed by their smaller brethren. The huge mirrors of these telescopes are used as giant light collectors focussing the feeble images of galaxies at the edge of the observable Universe.

The solution to atmospheric interference is, of course, to carry the telescope into space. Many science fiction stories of the 1950's centred on lunar observatories [2], where astronomers could work in near perfect observing conditions. A start in this direction was made in the late 1950's with the balloon-borne Stratoscope telescopes [1], but these missions only whetted the appetite of Earth-bound astronomers.

The arrival of powerful rockets at the end of the second world war provided an opportunity to send instruments into space, at least for short periods, and many of the so-called "new astronomies" were founded using surplus V-2 rockets. These missions were brief, with observing time measured in minutes, if not seconds, but when the first Earth satellites were launched the promise of orbiting telescopes, operating for months or years, was about to be fulfilled.

Telescopes in Space

The first satellites were small, unsophisticated vehicles but as technology advanced and more powerful rockets were developed, the way was opened for the launching of a variety of complex astronomical satellites. Freed at last from the atmosphere, orbiting observatories probed almost every wave-length of the electromagnetic spectrum which had, until then, remained totally inaccessible (See the separate section headed "Space-borne Observatories").



Paradoxically, it will be the oldest and best understood branch of astronomy that will be the last to benefit from observatories above the atmosphere. In 1985 NASA will launch its Space Telescope. This is a large unmanned reflecting telescope launched from the Space Shuttle and is expected to make possible outstanding advances in optical astronomy.

Development of the Space Telescope

Herman Oberth is reported to have proposed the establishment of an orbital observatory as early as 1943 [17] and occasional references to such a facility may be found in both science and science fiction after that date. Once the reality of orbital flight had been established, NASA commissioned two summer studies of a space telescope, held in 1962 and 1966. It was at these studies that the first detailed proposals for a space telescope and its scientific mission were made. In 1967 and 1968 an *ad hoc* committee of the National Academy of Sciences promoted a series of seminars on how such a spacecraft could be used, and focused the attention of the scientific community on the project.

NASA officially began the project as an advanced study in 1971 and 1972, the steering committee including several leading astronomers and engineers. This study is summarised in Ref. 18. At this time, the project was known as the Large Space Telescope and envisaged a mirror 3 m (10 ft) in diameter.

The scientific definition, led by Dr. C. R. O'Dell, was carried out between 1973 and 1976 when the mission objectives, modes of operation and preferred instruments were defined. It was during this study that a decision was made to reduce the size

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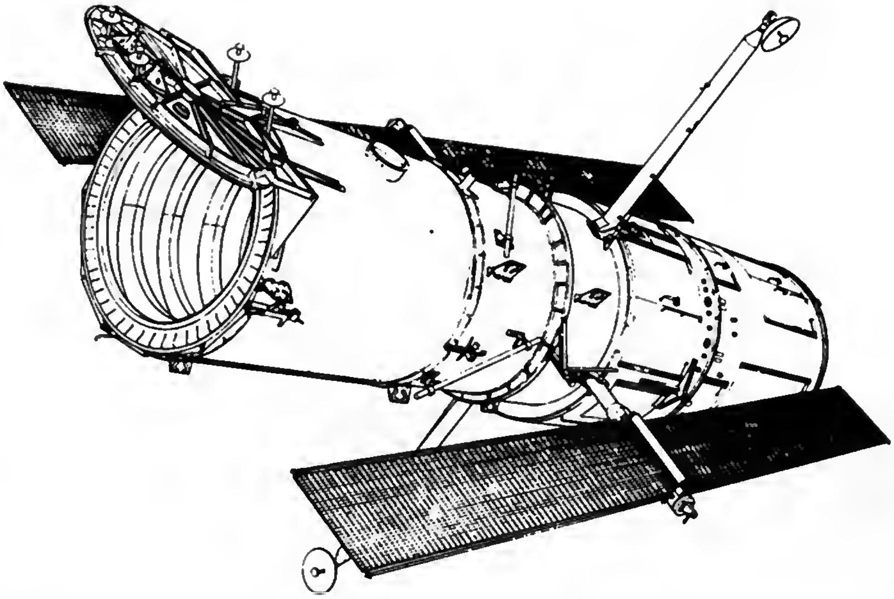
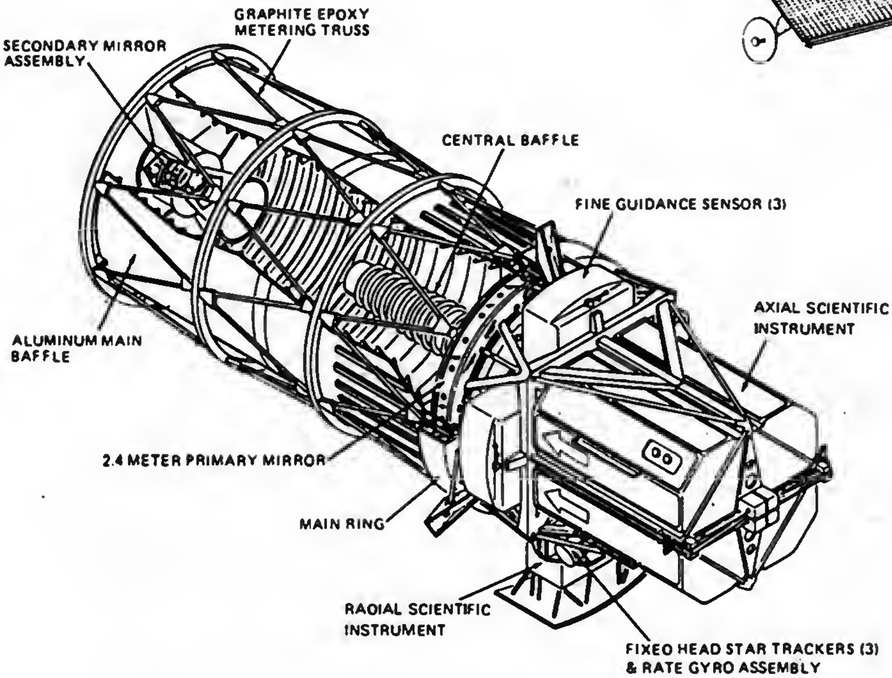


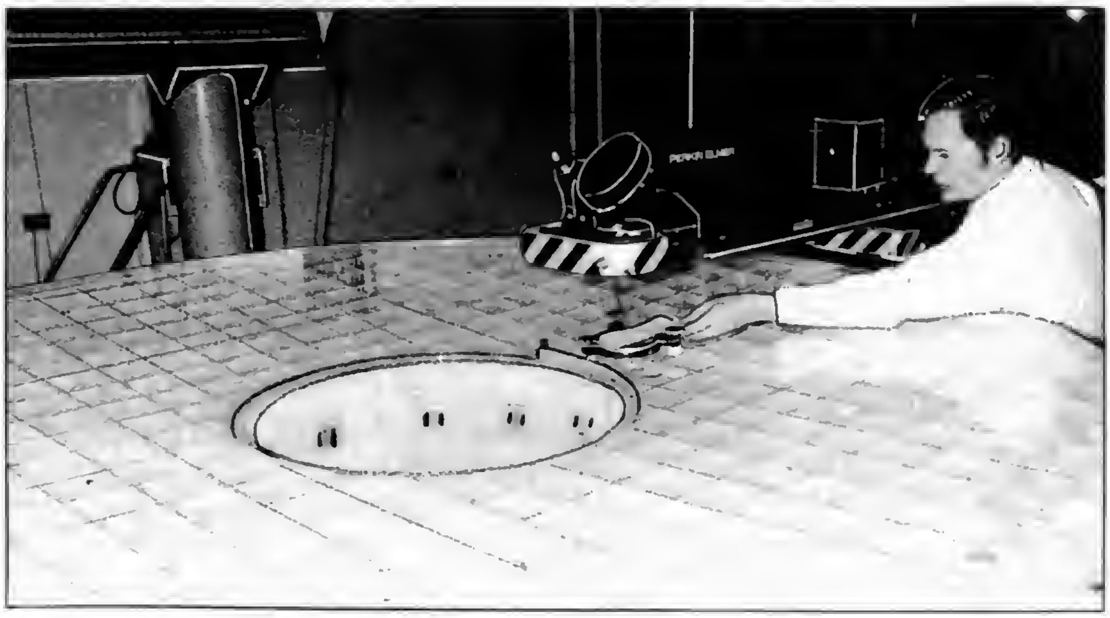
The Space Telescope as it will appear once deployed in orbit. The solar panels are rolled up into tubes during launch and unfurled in space. Astronauts will be able to service or replace equipment through the panels at the rear.

NASA



Main features of the Space Telescope. The experiments and their support equipment are positioned behind the main mirror. Light baffles prevent stray reflections from the structure reaching the instruments.

NASA



The 2.4 m main mirror after polishing but before coating. The light will reach the instruments through the central hole.

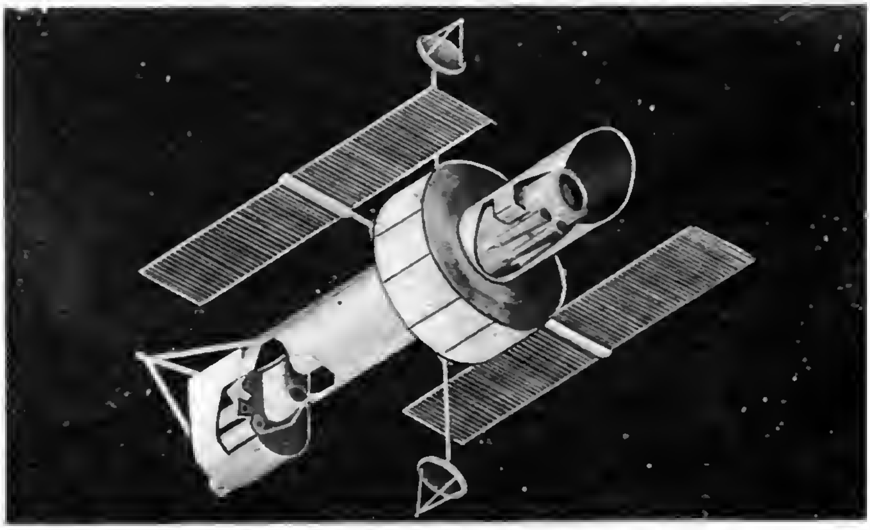
NASA

SPACE-BORNE OBSERVATORIES

The first dedicated astronomical satellites were the aptly named Orbiting Astronomical Observatories. OAO-1 was launched on 9 April 1966, but problems with its power systems caused contact to be lost before any scientific data could be gathered. The second OAO was more successful. Launched on 7 December 1968 it probed the Universe with its ultraviolet sensors for several years, far beyond its expected lifetime. A further OAO, Copernicus, was launched on 21 August 1972. This satellite was also very successful, remaining operational for over eight years [3].

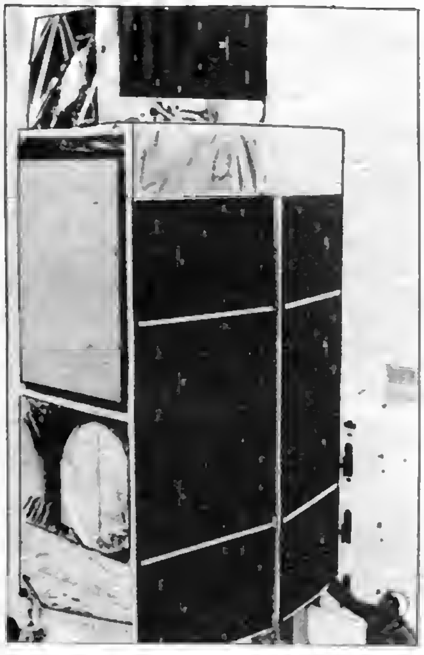
After the launch of OAO-2, a variety of other astronomical satellites were orbited. These varied enormously in size and complexity, but all were used to study radiation which does not penetrate to the surface of the Earth. 1970 saw Small Astronomy Satellite 1, or Uhuru. Launched on 12 December from the San Marco platform off the coast of Kenya, SAS-1 was used to make an initial survey of cosmic X-Ray sources [3,4].

Next into orbit, on 17 March 1972, was the European astronomy satellite, TD-1A. This orbiting observatory, Europe's first three axis stabilised spacecraft, made measurements of X-Rays, Gamma Rays, Cosmic Ray particles and ultraviolet radiation. After six months of operation it was placed in hibernation for 3½ months before being reactivated to complete its mission [5,6,7]. Later that year, the joint Dutch and American satellite ANS carried X-Ray and ultraviolet detectors [8,9].



NASA is considering an Advanced X-Ray Astrophysics Facility (AXAF) for launch in 1989. AXAF would operate in a 300 mi orbit for some 15 years, observing X-ray sources some 50 to 100 times weaker than those detected by HEAO 2. Mirrors are already being used for ground tests.

NASA



The third HEAO.

Following OAO 3, the fourth astronomy satellite of 1972 was SAS-2 (Explorer 48). Also launched from the San Marco platform, SAS-2 was to search for cosmic X-rays for a year or more, but a power failure ended the mission after only seven months [10,11].

Britain entered the astronomical satellite field in 1974 with the launch of the X-ray observatory Ariel 5. Ariel was a drum-shaped, spin stabilised satellite designed to operate for about six months. Despite depleted attitude control gas, Ariel 5 operated for over six years [12].

The third Small Astronomy Satellite (Explorer 52) was launched by a Scout rocket on 7 May 1975. It was designed to study specific X-ray sources discovered by SAS-1 [3].

Europe also launched an astronomy satellite in 1975. COS B, a Gamma Ray observatory, was launched on 9 August 1975. A spin stabilised satellite, COS B was designed to operate for a year, but as a precaution carried extra supplies of spark chamber gas for a possible two year mission. By good fortune and careful use of the gas, COS B remained operational well into 1982, when the gas finally ran out [13].

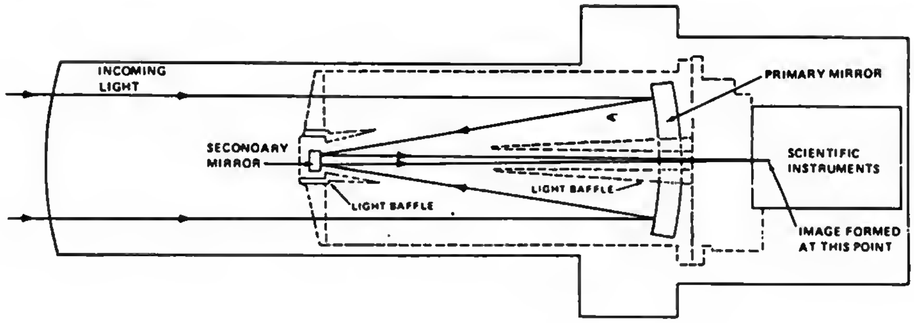
In 1977 NASA launched the first of three High Energy Astronomical Observatories, heavy satellites designed to investigate cosmic X-Rays and Gamma Rays. HEAO-1 carried out a sky survey mission locating X-Ray and Gamma Ray sources for future study. HEAO-1 operated for 17 months until its attitude control gas was exhausted in January 1979. The HEAO-2 ("Einstein") spacecraft was launched on 13 November 1978. This spacecraft was used to make detailed observations of the X-Ray sources discovered by HEAO-1. Similarly, HEAO-3, launched on 20 September 1979, was used for detailed studies of the Gamma-Ray sources detected by HEAO-1 [3,14,15].

Another important astronomy satellite of the late 1970s was the International Ultraviolet Explorer, IUE. Launched on 26 January 1978, it was funded by NASA, the UK Science Research Council and ESA. The IUE operates as an international observing facility, with individual astronomers responsible for gathering their own data by directing operations from a ground station [16].

So, by 1980, almost all the wavelength regions accessible from space had received intensive study. The infrared region was the only type of non-optical astronomy which had not been studied from orbit, and this omission will be rectified in 1983 by the launch of the Infra-Red Astronomy Satellite, IRAS [17].

The diagram shows how light enters the open end of the telescope, is projected from the primary to the secondary mirror, and is then directed to a focus inside the scientific instruments at the rear.

NASA



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of the primary mirror to 2.4 m (8 ft), a compromise between cost and the need to have as large a mirror as possible. At this point in the programme the word "Large" was dropped, the spacecraft being simply known as the Space Telescope.

With European activity in space increasing steadily throughout the 1970's and the needs of European astronomers in mind, the ESA proposed to NASA that they would take a 15 per cent share in the project. This decision was made on 6 October 1976 by ESA's Science Programme Committee [19]. The final agreement was that ESA would provide the spacecraft's solar panels and faint object camera. In return, European observers would receive 15 per cent of the observing time. The memorandum of understanding was signed in Paris on 7 October 1977 by Mr. Robert Frosch, Administrator of NASA and Mr. Roy Gibson, Director General of the ESA [20].

Formal confirmation of the project was announced on 14 December 1976 [21] and authorised by the US Congress in 1977. Final design and development activities began in 1977 and will continue essentially until launch. Competitions were held for contracts to construct various parts of the telescope and support systems. Kodak and Perkin-Elmer bid for the telescope itself and Lockheed, Boeing and Martin Marietta for the support module. The final awards were to Perkin-Elmer and Lockheed. Work on the primary mirror began in October 1977 with the casting of the blank at the Corning Glass Works in New York State. The blank was delivered to Perkin-Elmer in December 1978 when rough grinding began. Fine polishing began in August 1980 and was completed by May 1981 [17].

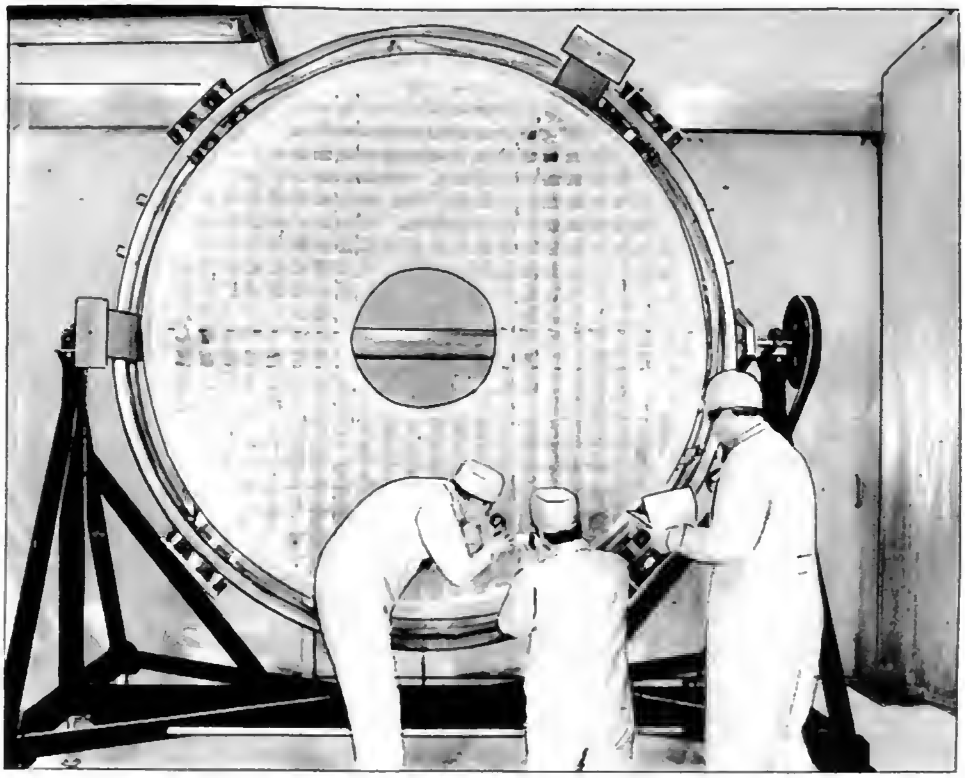
Project milestones are the final coating of the primary mirror, completion of the secondary mirror, and completion of the scientific instruments. All of these components will be delivered to Lockheed at Sunnyvale in California for assembly and check-out. The telescope will then be transported to the Kennedy Space Center in late 1984 for integration with the Space Transportation System and launch, scheduled for January 1985.

Spacecraft Description

The Space Telescope consists of three main elements, the telescope itself, its support systems module and the scientific instruments [17, 18, 22].

1. The Optical Telescope Assembly

The heart of the spacecraft is the telescope itself, a Cassegrain reflecting telescope of Ritchey-Chretien form [23]. Light is reflected from the 2.4 m diameter main mirror to a 0.3 m secondary mirror. This secondary sends the light back down the tube and through the centre of the primary to a focus 1.5 m



Inspecting the mirror surface before application of the reflective coating.

Perkin-Elmer

behind the primary. The tube contains a series of light baffles to suppress any unwanted light from other bright objects, such as the Sun or the Earth.

The primary mirror, 2.4 m in diameter and made of Ultra Low Expansion Glass, was prepared by the Perkin-Elmer Corporation. The mirror blank, weighing 907 kg (2000 lb), took three and a half years to grind and polish to the required accuracy. On completion in mid-1981, it was estimated to deviate no more than 0.000025 mm (one millionth of an inch) from the ideal surface. This is believed to be the most accurate telescope mirror ever produced.

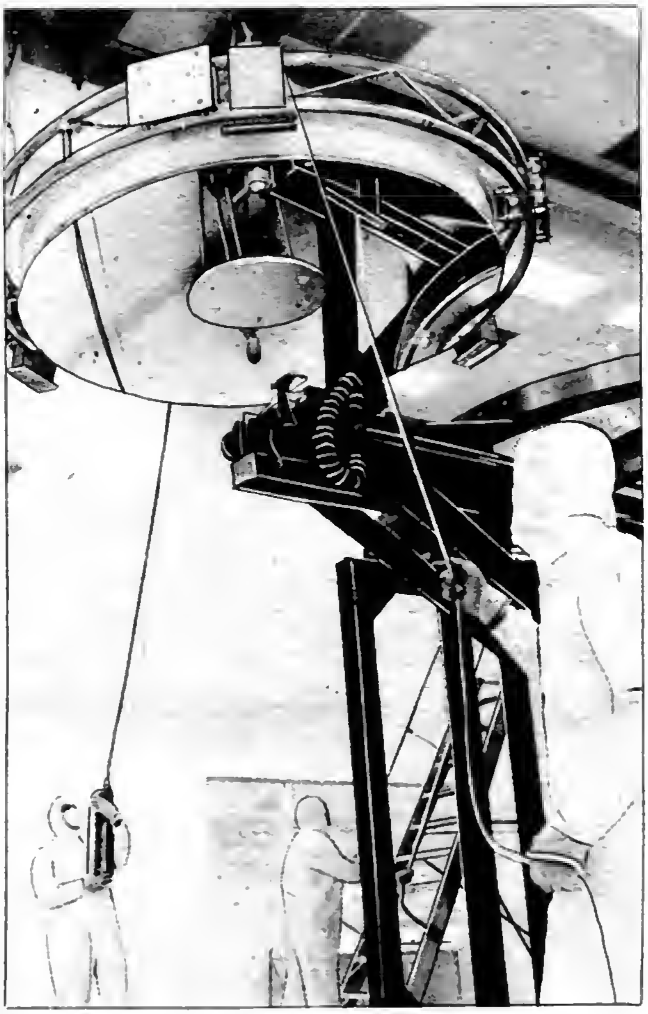
After completion of the basic mirror it was then necessary to coat the surface with a very thin reflective coating. This operation was carried out in a special stainless steel vacuum chamber, the largest of its type in the world. First a coating of highly reflective pure aluminium 0.00051 mm (0.00002 inch) thick was applied. This was followed by a protective coating of magnesium fluoride a mere 0.00015 mm (0.000006 inch) thick. The magnesium fluoride will protect the aluminium from oxidising and losing its reflectivity.

The small secondary mirror is also being ground and coated to the same exacting specifications to achieve the best possible optical performance.

To ensure that the two mirrors remain in the correct relative positions, despite the varying thermal environment, the telescope's main internal structure is fabricated from a graphite epoxy composite. Special optical-control sensors, located at the telescope's focal plane, will permit controllers to examine the optical condition of the telescope. Telemetered data will enable ground controllers to check the curvature of the primary mirror and the alignment of the secondary.

If errors are detected, the surface of the primary may be corrected by 24 force actuators mounted behind the back surface of the mirror. Six precision motors move the supporting structure of the secondary mirror to eliminate any mirror misalignments.

The combination of precision optics, adjustable mirrors and perfect observing conditions will make the Space Telescope a powerful observing tool. Almost every photon arriving at the main mirror will eventually be focussed at a point one quarter of the thickness of a human hair.



The Space Telescope main mirror after receiving its reflective coating of aluminium.

Perkin-Elmer

2. The Support Systems Module (SSM)

The SSM will supply the services required to operate the spacecraft. Basically it is a collar which fits around the telescope structure about level with the primary mirror. It contains the electrical power distributors and communications equipment, including the telemetry system and the attitude control gyroscopes.

The solar power array, provided by British Aerospace, consists of two identical deployable and retractable solar panels 11.82 m long with a total area of about 50 sq.m. The arrays, mounted on a double roll-out flexible substrate, will deliver over 4 KW of power at over 34V after two years in orbit. The panels will meet stringent requirements of reliability, both electrical and mechanical, and dynamic stability since they will be attached to a spacecraft with very accurate pointing requirements [24].

Attitude control is provided by a set of reaction wheels which receive their attitude information from rate gyroscopes, star trackers and fine guidance sensors. The wheels will allow the telescope to be moved through 90 degrees in no more than 20 minutes, including acceleration and deceleration. The star trackers will use bright stars to determine the pointing accuracy to within 1 arcmin which is sufficient to place the required guide stars in the fields of the fine sensors. These three sensors, located around the primary mirror, use interferometry to provide error signals to the attitude control system. The overall accuracy of this system will allow pointing and stability to within 0.007 arcsec.

3. The Scientific Instruments

The Space Telescope will carry five scientific instruments behind the primary mirror[18], each mounted in its own Scientific Instrument Module. These modules will be of standard sizes, completely independent and capable of operation without mutual interference. This arrangement allows any individual instrument to be removed completely or replaced with the minimum of effort. Replacement by Shuttle astronauts will allow the telescope's equipment to always be the most up-to-date available. The five instruments chosen as the payload for the first few years of operation are described below.

<u>The Wide Field/Planetary Camera (WF/PC)</u>

This instrument can be operated in two ways, characterised loosely by the two names: Wide Field Camera (WFC) and Planetary Camera (PC). The WFC mode, with a field of view of 2.7 arcmin square will be used for deep sky surveys. The PC mode is intended for high resolution imaging of faint sources over a smaller field of view.

The light entering the instrument is directed by a moveable, pyramid mirror to either the WFC or PC detectors. Both detectors consist of four sets of 800×800 charge-coupled devices (CCD), cooled to −95 degrees C, and coated with the organic phosphor, coronene. The coronene, which converts ultraviolet photons to visible photons, is used to increase the wavelength coverage of the detectors. Each CCD

array overlaps its neighbours, allowing the four separate images to be accurately recombined to a single large picture.

This instrument will provide a sensitive detector over the wavelength range from 1,150Å to 1.1 μm and a visual magnitude range of 8 to 28. Minimum exposure time will be 0.1 sec and typical long exposure times will be about 3000 seconds, corresponding to half an orbital period. It will be equipped with a large number of filters, transmission gratings and polarisers for specific observing needs.

The WF/PC will be located in a radial bay and will be cooled by an thermal radiator which will form part of the exterior surface of the spacecraft.

The Faint Object Camera (FOC)

The FOC [25] will use the full optical performance of the telescope to study very faint objects at high angular resolution. The FOC and WF/PC are complementary, since the FOC provides high spatial resolution and the WF/PC has a larger field of view.

The FOC consists of two independent camera systems operating at f/96 and f/48. When operated in the f/48 mode the field of view is four times that at f/96, but at lower resolution. At short wavelengths, very high resolution can be achieved by inserting a compact Cassegrain assembly into the f/96 optical path, providing an f/288 mode.

The detectors for the FOC are based on the Image Photon Counting System developed by Boksenberg. Essentially a very high performance image intensifier, the IPCS is able to count individual photons, allowing the study of very faint objects. By using integration times of up to ten hours, it should be possible to achieve a signal to noise ratio of at least 4 for stellar objects as faint as visual magnitude 28. Like the WF/PC the FOC will be equipped with a variety of filters and polarisers. In the f/96 mode a coronographic facility is included to suppress the light from bright objects when observing faint sources in the same field. The f/48 system provides a long slit spectrographic capability for observing extended objects such as galaxies, comets and nebulae.

ESA will provide the FOC as part of the European contribution to the project. Located in an axial bay the FOC has dimensions of 0.9×0.9×2.2 m, weighs 318 kg and will consume about 140 W over a typical 95 minute orbit.

The Faint Object Spectrograph (FOS)

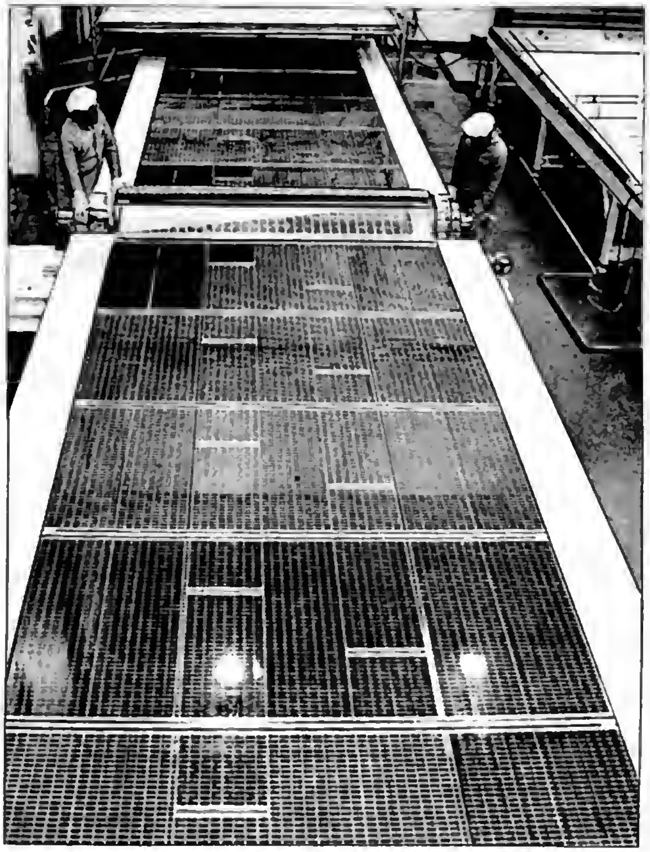
The Faint Object Spectrograph will be used for moderate and low resolution spectroscopy at both visible and ultraviolet wavelengths. It can also be used for spectropolarimetry and time-resolved spectroscopy.

The FOS uses two magnetically focussed, photon counting Digicon sensors, one covering the ultraviolet and visible wavelengths, the other the visible and near infrared. The Digicon operates by re-imaging the detected photoelectrons onto an array of 512 silicon diodes. Exposure times will vary from a minimum of 50 microseconds to 10,000 seconds or more. A continuous set of exposures, each of duration 50 μsec to 10 msec, can be made at rates of up to 100 exposures per second, allowing accurate, time-resolved spectroscopy.

The faintest stars visible (the limiting magnitude) to the FOS will vary with the wavelengths studied and the resolution selected, but is expected to be about 21st magnitude at high resolution and 25th magnitude at low resolution, for a 10,000 second exposure.

The High Resolution Spectrograph (HRS)

The HRS will provide high quality spectra at ultraviolet wavelengths between 1100 and 2300Å. The instrument may be operated in one of three resolution modes, but only the high and moderate ranges will normally be used. In the highest resolution mode the resolving power will be of the order of



One 'wing' of the two solar arrays which will provide 5 kW to operate the Space Telescope. The array blankets are stored on a drum with Kapton cushioning between to prevent the cells touching.

British Aerospace

10^5. The moderate resolution mode will be used for target acquisition, estimating exposure times for high resolution spectra and coverage of the short wavelength region, where high resolution spectra are impractical because of the low efficiency of the OTA.

Like the FOS, the HRS uses two Digicon detectors each with 512 diodes. Minimum exposure time will be 25 msec when data is transmitted to the ground directly and 50 msec when the data is stored on board. Limiting visual magnitudes will vary with wavelength and resolution mode, but for a 2,000 second integration, will be about 11 at high resolution, 14 at medium resolution and 17 at low resolution.

The High Speed Photometer (HSP)

The High Speed Photometer will be used to study the time-dependent brightness fluctuations of a variety of objects over a wide wavelength range. It is capable of resolving two events a mere 16 μsec apart. This level of resolution is impossible from Earth because of fluctuations in the atmosphere.

The HSP uses four image dissectors (essentially photomultipliers with spatial resolution) and a red sensitive photomultiplier. Two of the image dissectors operate at ultraviolet wavelengths, the other two in the visible and near ultraviolet. This array of detectors allows a wide wavelength coverage from about 1200 to 8,000Å. Unlike a conventional photometer, which uses a stepping motor to position various filters in the optical path of the instrument, the HSP contains no moving parts. The choice of filter and aperture combination will be made by positioning of the optical image within the HSP by small movements of the telescope.

The HSP will operate in one of three modes. The first is for

The main mirror being prepared for interferometric tests to measure the "figure" of its surface.

Perkin-Elmer

star-sky photometry with a single filter. This allows the brightness of the local starfield and nebulosity to be subtracted from the stellar magnitude to improve accuracy. The second is for photometry or polarimetry with several filters used sequentially with small motions. The third is for wide field photometry over a 10 arcsec diameter area without a filter, requiring no special spacecraft motion.

Limiting visual magnitude with a 1,000 second integration time and signal to noise ratio of 10 will be 24. Photometric accuracy is expected to be about 0.2 per cent.

Astrometry with the Fine Guidance System

During normal operations, two of the three Fine Guidance Sensors will be used for accurate telescope pointing. The third sensor will be available for astrometric measurements, which will be both accurate and short.

With the aid of neutral density filters, stars with magnitudes between 4 and 20 should be measurable, with positions of ten stars being determined in about ten minutes. Possible targets include both distant stars and the satellites of the outer planets.

Mission Operations

In 1985 the Space Telescope will be carried into orbit by Shuttle STS-23 from Cape Canaveral. Once in orbit, the Shuttle will use its orbital manoeuvring system to raise itself to the required 500 km circular orbit. The telescope will then be removed from the Orbiter's cargo bay and positioned in space by the remote manipulator arm. Before release, it will receive a preliminary check-out by ground controllers.

Once released, the solar panels will be deployed and the main cover opened. With the Orbiter still standing by, the telescope will be given a thorough system check lasting several days. Only when ground controllers are satisfied that the spacecraft is fully operational will the Shuttle return to Earth. Should a problem occur which cannot be cured *in situ*, the telescope will be reloaded into the Orbiter cargo bay and returned to Earth for repairs. Once the telescope has been declared operational, control will be handed over to the Space Telescope Science Institute which will conduct routine operations and co-ordinate research workers from both the USA and other countries. Although in orbit, it will be operated like a large ground based observatory. Astronomers will be allocated observing time based on both the importance of their observations and the availability of suitable instruments on the telescope. Astronomers will probably travel to the Institute to carry out their observations, allowing them to make on-the-spot judgements during their allocated observing session.

After about two and a half years in orbit, the Shuttle will again visit the telescope. It will be grappled by the remote manipulator, its solar panels folded and slowly positioned back in the cargo bay. Shuttle astronauts will "space walk" to the telescope and replace some, or all, of the scientific instruments. Other routine servicing tasks will be carried out while it is within the cargo bay. Once these operations are complete, it will be released again and returned to ground control.

After another two or three years in orbit the telescope will be collected by a Shuttle and returned to Earth complete. After landing at the Kennedy Space Center, it will be taken to another establishment, probably the G. C. Marshall Space Flight Center, for a complete overhaul. The mirrors and solar cell arrays will be removed and returned to their manufacturers for refurbishment and new scientific instruments will be installed in the main structure.

After reassembly and checkout, the telescope will be returned to Cape Canaveral for relaunch and another five year period in space. By regular servicing and periodic returns to Earth, the Space Telescope is expected to remain operational until into the next century.

Use of the Observatory

Since the ST will be controlled from the ground and scientific information will be returned to Earth, a reliable two way communications link is essential [18]. Communication with the spacecraft will be via ground antennae and a pair of geostationary Tracking and Data Relay Satellites. Although com-

munication should be possible for about 85 per cent of each orbit, the demands on the system by other users is expected to reduce communication time to about 20 per cent. This will mean that real time control of the telescope will not normally be possible.

Consequently, the ST will be operated in a more automatic manner than most ground-based telescopes. Most observations will be pre-programmed, with a sequence of commands being sent up and stored before being executed automatically. For some observations of unusual or irregular sources a variety of alternatives will be pre-programmed with the scientist able to choose between them in real time. These observations will be made in specifically assigned blocks when near continuous communication is possible.

To allow a quick look at the data, both for interest and to allow checking of the choice of observation in use, some of the received data will be relayed to the Scientific Institute. Although "noisy", this data will allow a preliminary assessment of the success of the observation and the necessity of changing the observing plan. The quick-look data should be available within a few minutes of the observation.

Once the final data have been received, checked, reduced and delivered to the scientist responsible, the investigators will be allowed a period of one year to study and publish their results. After this period, the data will be made available to all the scientific community for general use. Exemptions to this rule will be made on a case-by-case basis for observations which, by their nature, must last for much longer periods, e.g. measurements of stellar parallax.

Since the telescope's field of view allows more than one instrument to operate simultaneously, joint observing programmes will often be possible. An example might be the monitoring of variable stars while other instruments are studying one of the Magellanic clouds. Similarly, exposures may be made by the WF/PC whilst another observation is in progress. The extra data collected will be known as "serendipity data" and will be immediately available to any user who submits an acceptable programme.

Conclusions

The power of the Space Telescope will allow observers to reach seven times further into space, possibly seeing for the first time objects at the edge of the observable Universe. The detailed structures of quasars should be visible for the first time allowing astronomers to probe the energy sources of these cosmic powerhouses. Closer to home, we can expect more detailed observations of nearby galaxies, possibly leading to a revision of the cosmic distance scale. This in turn may lead to a clearer understanding of how the Universe was formed.

Within our own Galaxy the detailed structure of gaseous nebulae will be studied and a search for planets of nearby stars embarked upon. Even Solar System studies will be possible, using the telescope to monitor the weather on the outer planets and to study smaller bodies such as comets or asteroids.

Ultimately though, the history of science has shown us that the most important discoveries will probably be those which have not even been considered today. The Space Telescope will open a new era in optical astronomy. Who can tell what it will bring?

Acknowledgements

The Author would like to thank the following organisations for their help in preparing this article: NASA Goddard Spaceflight Center, Fokker BV, European Space Agency, Perkin-Elmer Corp., British Aerospace Dynamics Group, TRW Defense and Space Systems Group and the General Electric Space Division. Also thanks to Marilyn for typing the manuscript and to Paul and Maggie for proof reading.

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VENUS RADAR MAPPER MISSION

The late, lamented Venus Orbiter Imaging Radar (VOIR) mission was cancelled by the Reagan administration in January 1982 for budgetary reasons. JPL mission designers reviewed the remaining Venus-exploration options and came to the conclusion that ellipses are cheaper than circles. The VOIR mission would have placed a synthetic-aperture radar (SAR) 250 km above the planet in a circular, near-polar orbit, with the intention of mapping most of the planet to a resolution of about 600 m. The Venus Radar Mapper (VRM) mission would place a SAR-equipped spacecraft in orbit about Venus for global mapping at about 1 km resolution but would not circularise the orbit.

Eliminating the need to circularise the orbit, which would have been done by mass expulsion or aerobraking, results in a simpler, less expensive spacecraft design. Since mission costs are almost always dominated by the expense of the spacecraft, it is clear that significant cost savings might result. In fact, the total mission cost has been cut approximately in half, to under a run-out cost of $300 million dollars. In order to achieve these savings some atmospheric science which was planned for VOIR had to be excluded from VRM.

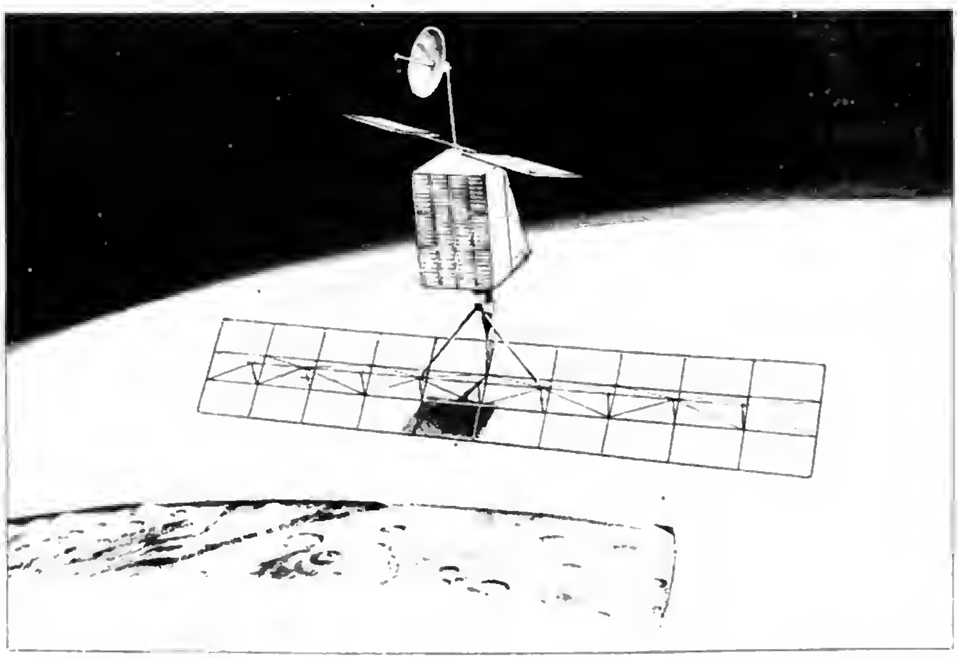
Despite previous missions to Venus by the United States and Russia, Venus is the only terrestrial planet which has not been characterised geologically. The status of exploration of the second planet has been likened to that of the United States in the early 1800's when the gross physiography was known, but not the geologic processes which shaped it. The smaller terrestrial planets (Moon, Mercury and Mars) have been fashioned by two major geologic processes: impact cratering and vulcanism. In addition, they are one-plate planets with a single, global lithospheric plate. They also possess ancient surfaces, over 2.5 thousand million years old, which are largely unmodified since the time of the early Solar System. These planets are in distinct contrast to the Earth, and a primary question is how Venus fits into this geological dichotomy.

The basic mission plan for VRM consists of an April 1988 launch from the Shuttle with a Centaur upper stage and an arrival at Venus in July 1988. The nearly 900 kg spacecraft will be inserted into a 3.7 hour elliptical orbit inclined at 83.8 degrees to the Venusian equator.

A global model of Venus derived from radar data returned by the Pioneer-Venus mission. A dedicated Venus mapper would allow us to reconstruct the surface in much greater detail.

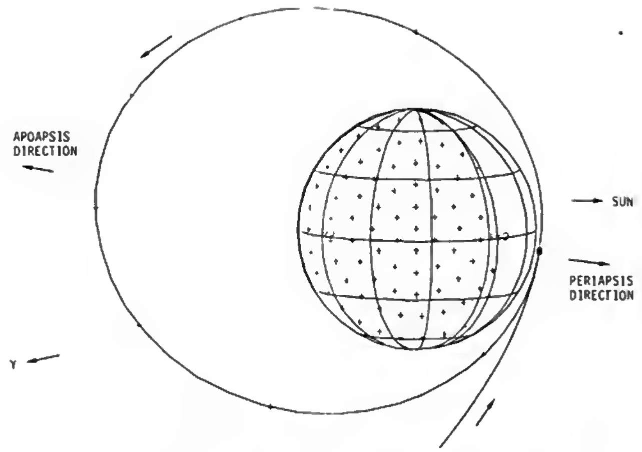
NASA

The mapping strategy will employ the same antenna for collecting data (at a rate of over 600 kilobits per second) that will be used to transmit the science data to Earth, at 230 kilobits per second. On every orbit, the planet will be mapped by the SAR at 71 degrees on each side of periapsis, about 41



The old Venus Orbiter Imaging Radar (VOIR) was dropped earlier this year because of the cost. Since then, JPL has been studying a simpler, cheaper spacecraft mission. It has yet to be approved.

JPL



This view of the Venus Radar Mapper (VRM) orbit is from a perspective point which is perpendicular to the plane of the elliptical orbit. Data from the synthetic-aperture radar are collected in the region of periapsis, then the spacecraft is reorientated for their transmission to Earth in the region of apoapsis. In this computer-drawn figure, the shading represents the night portion of the planet.

JPL

minutes total time per orbit, and the antenna will then be reoriented toward Earth for playback of the tape-recorded data. This mode of operation results in the planet being mapped at a range which varies from 250 km at periapsis to 1900 km at ±71 degrees true anomaly.

The side-looking radar will map 92 per cent of the surface of Venus at 1 km resolution if all goes according to plan. Only small polar caps in the north and south will be excluded; they may be included in the map but at lower resolution. The total mission requires eight months in orbit, with the mapping being completed just as Venus enters into solar conjunction.

The project manager for VRM is John Gerpheide, who played a key role as spacecraft manager in the highly successful Seasat mission which first demonstrated the value of the SAR as a planetary-mapping device. A second application of SAR technology took place with the SIR-A experiment on the third flight of the Shuttle (see "Space at JPL" in the September-October issue). It is clear that the SAR technology would not only be useful in penetrating the cloud cover of Venus but could also provide that service for a Titan mapper mission or a search for sand-buried water features on Mars (SIR-A traced out ancient drainage patterns under the dry sands of the Sahara).

The VRM mission has been presented to NASA with the intent that it be formally initiated as a project as early as October 1983, pending approval by NASA, the Reagan administration and Congress.

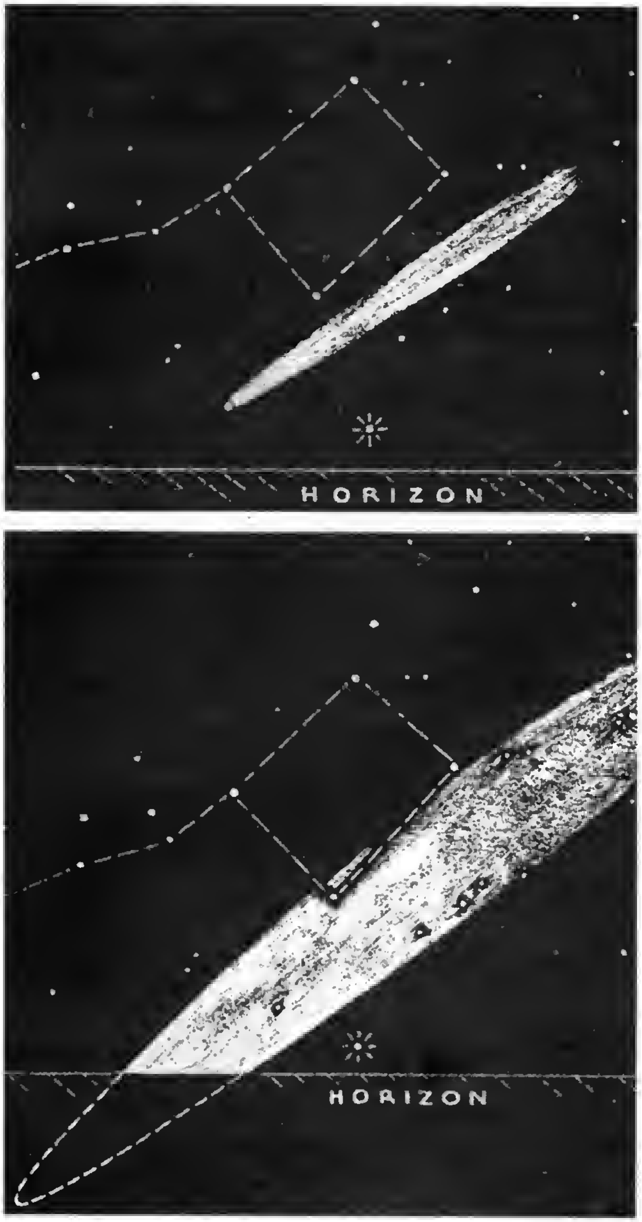
INTERNATIONAL HALLEY WATCH

An international network of professional and amateur astronomers is being organised to observe Halley's comet during its next perihelion passage in 1986. The organisation is called the International Halley Watch (IHW) and will be led by Ray Newburn of JPL and Dr. Jurgen Rahe, director of the Remeis Observatory of the University of Erlangen-Nurnberg in the Federal Republic of Germany.

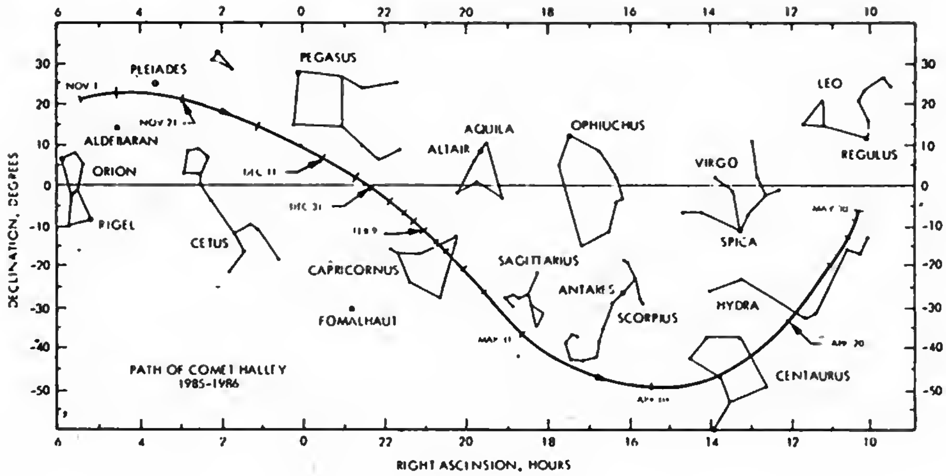
The basic function of IHW will be to coordinate observations of Comet Halley and to collect data from ground-based observations, balloons and airborne and Earth-orbital instruments. Close coordination will also be maintained with the three projects that are sending spacecraft to fly by the comet. The ultimate product of IHW will be the Halley Archive, the largest collection of information ever produced on a single comet.

Dr. Louis Friedman first proposed the concept of an IHW to NASA in the summer of 1979 while at JPL. The idea was developed under a small grant from NASA, and from the very beginning emphasis was placed upon making IHW a truly international effort. With the departure of Friedman from JPL to serve as the Executive Director of the Planetary Society, Newburn was appointed as Leader and Rahe as Co-Leader of the IHW. Two offices were established: one in Pasadena, California managed by Newburn and the other in Bamberg (FRC) managed by Rahe.

Experiment teams supported by the IHW have been grouped into seven major categories, each with a discipline



Top: Halley's comet in the eastern sky as sketched by C. C. Wylie on 14 May 1910. The brightest star-like object is Venus. The star patterns of Pegasus and Andromeda are outlined. For the 1986 apparition of the comet, the International Halley Watch is soliciting observations from professional and amateur astonomers. The primary use of the amateur-supplied observations will be to compare them with similar visual and photographic data from the 1910 event. *Below:* Halley's comet on 18 May 1910.



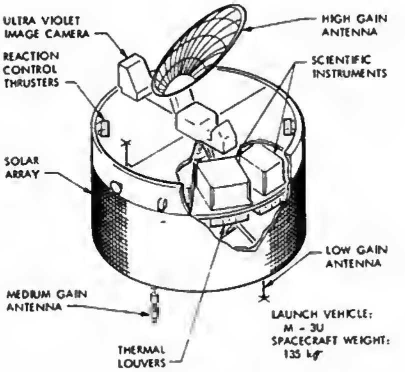
The path of Halley's Comet across the sky for November 1985 to May 1986. It will probably be best visible after perihelion, in the southern constellations.

NASA/JPL

specialist assigned to it:

1. Large-scale phenomena studies using wide-angle photography to image the tail (Dr. John C. Brandt of NASA's Goddard Space Flight Center),
2. Near-nucleus studies focusing on rotation rate, surface studies, and general activity (Dr. Rahe),
3. Spectroscopy and spectrophotometry yielding data on the physical composition of the nucleus, coma, and tail (Dr. Susan Wyckoff and Dr. Peter Wehinger of Arizona State University),
4. Photometry and polarimetry for determining abundances and distribution of components of the coma and tail (Dr. Michael A'Hearn of the University of Maryland),
5. Infrared spectroscopy and radiometry measuring the temperature, size and composition of released dust particles and, possibly, identification of gaseous components (Dr. Roger Knacke of the State University of New York),
6. Radio science studying the chemical composition and kinematics of coma, nucleus and tail, plus plasma studies (Dr. William Irvine of the University of Massachusetts),
7. Astrometry supporting the accurate determination of the comet's orbit (Dr. Donald Yeomans of JPL).

The astrometric work is not only of value for the knowledge that it will yield on the magnitude of nongravitational forces such as outgassing from the nucleus; the updated ephemeris will play an important role in the navigation of the flyby spacecraft of ESA, Japan and the Soviet Union.



The Japanese Halley probe, Planet-A, will carry 10 kg of experiments.

The Amateur Observation Net of IHW will be coordinated from the Pasadena office. Several methods of communication are planned: a newsletter, direct mail interaction with network participants, articles in general science and astronomical magazines, comet sessions at amateur conventions, and a looseleaf IHW Amateur Observer's Manual. The participation of both amateur and professional observers is reminiscent of their successful collaboration for the optical tracking of the Apollo spacecraft (see the October 1971 issue of *Spaceflight*).

Observers who are interested in participating in the IHW work should indicate their area of interest and write to either Mr. Ray L. Newburn, Jr., MS T-1166, Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109; or, Dr. Jurgen Rahe, Director-Remeis Sternwarte, Sternwartestrasse 7, D-8600 Bamberg, West Germany.

NEW DIRECTOR FOR JPL

Dr. Lew Allen, Jr. assumed the post as Director of JPL in October. In addition to the lead role at JPL, Allen was also named as a Vice President of the California Institute of Technology, which operates JPL. Until his retirement from the US Air Force last June, Allen held the rank of general and was the Air Force's Chief of Staff and a member of the Joint Chiefs of Staff. He has a Ph.D. in physics from the University of Illinois.

With the selection of Allen it is clear that Caltech and JPL plan to move actively and aggressively to meet the challenges to the Laboratory that have been posed by the erosion of its traditional market: interplanetary missions for NASA. The new director brings three obvious strengths to the Laboratory: administrative ability demonstrated by leading a combined military and civilian workforce of nearly one million people, experience in space systems acquired by heading several of the Air Force's top satellite and missile programmes, and an insider's knowledge of Washington and the military. JPL may devote up to 30 per cent of its activity to military projects in the future.

The basic commitment of JPL to the exploration of space for scientific purposes was underscored by Allen's appointment as a Vice President of Caltech. In addition he has stated, "JPL has done magnificant things in planetary exploration. I intend to seek the support of space scientists and do the best I can to continue that record of achievement."

Lew Allen was born on 30 September 1925 in Gainesville, Texas. He graduated in 1946 from the US Military Academy at West Point and received his Ph.D. in physics in 1954 from the University of Illinois (Thesis: "Photo Disintegration of Deuterium by Ninety-Five MeV X-Rays"). He worked as a research physicist at Los Alamos Scientific Laboratory and, in

1957, became science adviser to the Physics Division of the Air Force Special Weapons Center.

In 1962 he worked in the Space Technology Office of the Secretary of Defense. From 1965 to 1973 he served in the Office of the Secretary of the Air Force in several roles, including that of Director of Space Systems at the Pentagon, and Director of the Space and Missile Systems Organization. From 1973 to 1977 he held several national security posts and in 1977 was named as commander of the Air Force Systems Command.

NAVIGATING BETWEEN THE PLANETS

In his classic introductions to astronautics, "Interplanetary Flight" and "The Exploration of Space", written in the early 1950's, Arthur C. Clarke correctly foresaw most of the ingredients of modern interplanetary navigation: radio and optical tracking, midcourse-correction manoeuvres, landing radars and the necessity for high-speed computing machines, both onboard the spacecraft and on Earth. The JPL navigation system represents NASA's institutional capability for deep-space missions and is the fruition of Clarke's 30 year old forecast.

Dr. J. F. Jordan, the manager of JPL's Navigation Systems Section, defines astronautical navigation as "the process of locating the position and predicted flight path of a space vehicle and correcting that predicted flight path to achieve mission objectives." The amount of supporting equipment and processing that is required belies this matter-of-fact definition. In addition to the antennae of the Deep Space Network that detect the returning radio signals, more than 20 major computer programs are employed to process the signals and yield flight-path related products. One measure of the complexity of this processing is furnished by the combined length of the Fortran code which comprises these programs: approximately 750,000 lines. If the programs were stored on standard IBM cards, they would form a rather precarious stack about 450 ft tall!

The navigation system is efficiently integrated into the mission and spacecraft systems at almost every level. The camera employed in optical navigation by the spacecraft is the same one that returns images of the planets and satellites, radio-system navigational usage is shared with the return of scientific data and engineering telemetry, and the ground-based processing takes place on the Laboratory's general-purpose computer, a Univac 1100/81. The onboard command sequences that are required in order to accomplish course-correction manoeuvres must share the storage space that is available in the spacecraft computer. Sometimes the sharing can necessitate a dash of inventiveness in order to satisfy the needs of all of the systems. At the Voyager 2 encounter with Jupiter, a course correction was required so that the conditions for a later encounter with Saturn would be optimal, but during this period the spacecraft computer was heavily loaded with command sequences related to the gathering of scientific data. A solution to the potential conflict over computer usage was achieved when it was realised that at a certain time in the science sequences the spacecraft's thrust axis would be aligned in the proper direction for the manoeuvre, thus saving the computer space normally required for the alignment commands.

The accuracy obtainable from the orbit-determination process is a function of many factors (for example, the accuracy resulting from the doppler method decreases as the spacecraft nears the celestial equator), but in general the accuracy of radio methods, which are Earth-based, decreases with distance from Earth while the optical-navigation technique improves as the target body is approached. Thus, they are complementary. As Jordan phrases it, "Radio navigation is somewhat analogous to traditional nautical dead-reckoning, since it relies on measurements relative to the origin of travel. Optical navigation is essentially a piloting system, since it relies on destination-relative measurements."

An idea of the accuracy that the system can deliver is gained by quoting the delivery accuracy of Voyager 1 at the Galilean satellite Io: 100 km relative to that body, at a range of hundreds of millions of kilometres.

The utility of the navigational system goes beyond the engineering function of navigation itself. The measurement and determination of influences upon the flight path of the spacecraft extends, of course, to the natural environment as well as propulsive manoeuvres, so that the masses and other gravitational parameters of planets and satellites that are approached sufficiently close can be accurately determined, far better than can be done by Earth-based methods.

The technique of radio-doppler navigation was the primary method employed in the 1960's and early 1970's and reached its apex in the Mariner 9 and Viking missions to Mars (an in-depth study of this technique is contained in a JPL report on Mariner 9 navigation which was reviewed in the April 1975 issue of *JBIS*). The feasibility of optical navigation was demonstrated on Mariner 9 and Viking, and it has played a major role in Voyager navigation.

New challenges and the development of new techniques will come with future interplanetary missions: Galileo, Venus Radar Mapping Mission (VRM), the European spacecraft in the International Solar Polar Mission (ISPM), and others on the drawing boards such as the Starprobe close encounter with the Sun. A technique of promise is that of Very Long Base Interferometry (VLBI), which allows the determination of positions with respect to the most distant objects in the Universe: quasars. According to Jordan, "VLBI will be used primarily in the 1980's for precision reconstruction of orbits, but could eventually replace doppler as the primary radio-navigation measurement, if the planetary ephemerides are improved during the next decade and computed in a quasar-related coordinate frame."

With the more recent emphasis on Earth-orbiting missions, the Laboratory is applying its navigational expertise to certain classes of Earth satellites, consistent with the overall NASA tracking plan. One advanced technique that is being investigated by A. R. Khatib of JPL for Earth-satellite navigation involves the placement of two reference beacons on the Moon. The method shows promise for enabling highly-accurate determination of satellite orbits. It is interesting to go back to Clarke's "Interplanetary Flight" and read a variant of this method, "a transmitter on Earth with a 'slave' on the Moon could produce a set of position-lines filling an enormous volume of space . . ."

THE CROWDED SKY

THE DANGER OF COLLISIONS IN GEOSTATIONARY ORBIT

By Nicholas L. Johnson*

Just as world attention has been focused in recent years on pollution of the atmosphere and oceans, so too can the pollution of space have far-reaching effects. The attitude of the majority of space-faring organizations has led to the present situation in which *operational* satellites account for only a small portion of the more than 4600 man-made objects currently known to be in orbit. While the probability of two satellites bumping into each other is today relatively low, prospects for the future do not appear as bright [1,2].

Introduction

One of the most important regions in space is the Clarke orbit: that region of space in which a satellite appears to hover motionless over a point above the equator. The geostationary orbit (as it is more often called) represents a unique and valuable international natural resource. Like most natural resources it is not limitless. Once it has been over-exploited and contaminated, restoration may be impractical and/or uneconomical. We are already beginning to feel the effects of our nonchalance.

The first successful geosynchronous satellite, Syncom 2, was launched in July 1963. However, its nearly 36000 km altitude orbit was inclined at some 32 degrees to the equator, forcing the satellite to trace a figure-eight pattern a third of the way into the northern and southern hemispheres. In 1964 the first truly geostationary satellite, Syncom 3, was launched and successfully deployed. Since then, over 130 satellites have duplicated this feat while many more satellites and spent rocket stages have been placed in slightly more inclined or more eccentric 24-hour orbits. By April 1982, NORAD was actively tracking 150 identified, unclassified bodies in near-geosynchronous orbits and more than 50 further objects which regularly traversed the geostationary regime. This does not include older satellites which have been "lost" or certain classified satellites. In addition there are an estimated 1000–2000 objects with surface areas between 1 cm^2 and 1 m^2 which populate the geosynchronous regime and are currently untrackable by the Space Detection and Tracking System (SPADATS).

Geostationary satellites have been fostered by a wide variety of countries and organizations: NASA (1964), COMSAT (1965), USAF (1968), United Kingdom (1969), NATO (1971), Canada (1972), USSR, Western Union, and France/Germany (1974), RCA (1975), Indonesia (1976), Japan, Italy, ESA (1977) and the US Navy (1978). *Spaceflight's* "Space Communications" section is an excellent source of information on many of the newest and planned geostationary satellites. Most perform communications or meteorological functions. Some are multi-purpose satellites, while others serve more military objectives such as early warning and electronic intelligence.

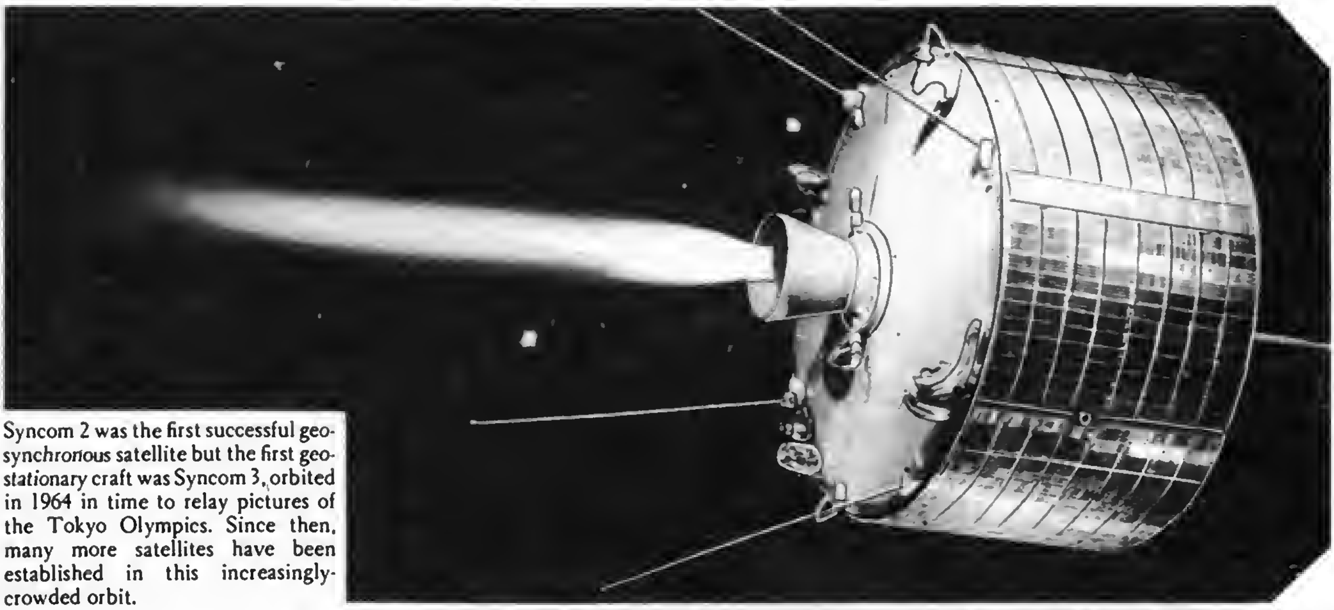
The fourth illustration shows the growth of geostationary satellites during the past 18 years. The general trend is obvious, and plans by a large number of organizations call for significant increases in the geostationary population during the remainder of this century [3–4].

The Dangers

With this rapid growth in the geostationary regime, what are the real dangers to satellite operations? Basically, there are two: radio frequency interference and physical collision. Radio frequency interference (RFI) is a straightforward problem which lends itself to a moderately simple technical solution, even if political influences complicate the issue. Here on Earth we have long contended with the interference of separate radio or television stations which operate on similar frequencies and are physically close to one another. Satellites which rely on uplink (Earth-to-space) and downlink (space-to-Earth) radio transmissions can also be disrupted by the presence of foreign transmissions on nearby frequencies. Therefore, not only the locations of satellite transceivers but also the location of Earth terminals and the required transmission power levels must be regulated to prevent international chaos.

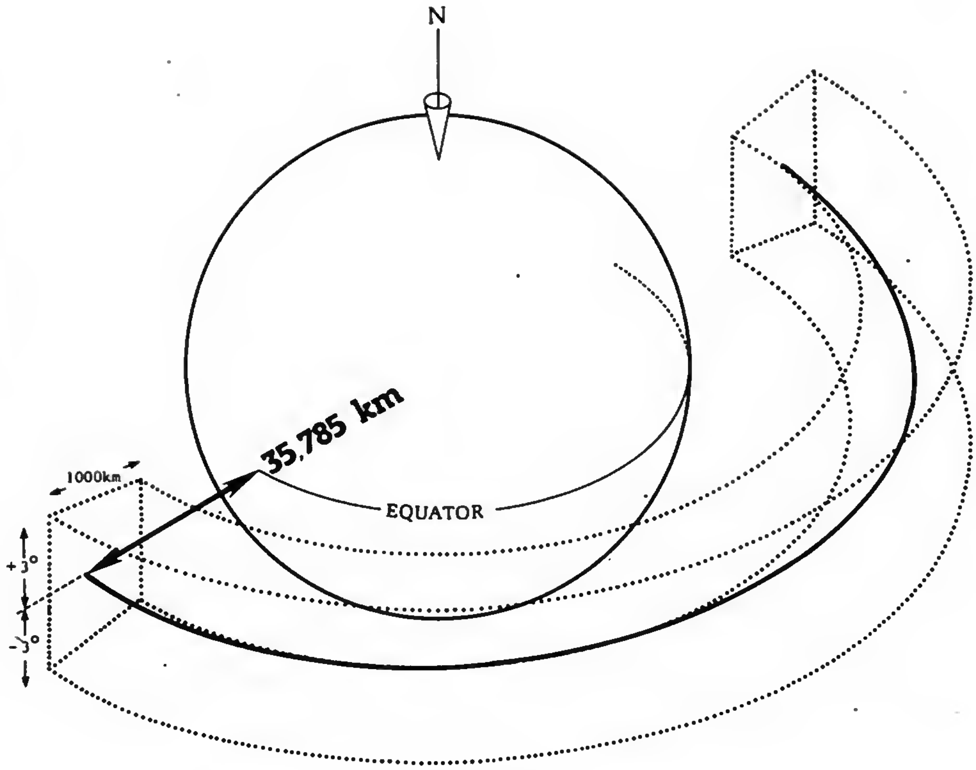
This task is currently a function of the International Frequency Registration Board (IFRB) and the World Adminis-

* *Principal Technologist, Teledyne Brown Engineering, Costa Mesa, California.*



Syncom 2 was the first successful geo-*synchronous* satellite but the first geo-*stationary* craft was Syncom 3, orbited in 1964 in time to relay pictures of the Tokyo Olympics. Since then, many more satellites have been established in this increasingly-crowded orbit.

The operational geostationary regime. Although the geostationary ring can be defined quite narrowly, operational requirements dictate that the wide region shown here be considered when discussing such orbits. As large as the geostationary orbit may appear (a circumference of 265,000 km), certain locations are considered prime sites by competing countries and organisations. A recent example of this is the dispute between Japan and the Soviet Union over the 130°E location [6].



trative Radio Conferences (WARCs) of the International Telecommunications Union (ITU). The ITU has specific guidelines which demand minimum separations between satellites in the geostationary orbit which operate on similar uplink and downlink frequencies. Although future technological advances might alter the situation, most geostationary satellites today operate in only a few narrow bands of the radio spectrum. Consequently, there has developed a *de facto* assignment procedure which reduces the number of satellites in a given equatorial location. However, as more diverse telemetry techniques are incorporated and as the number of satellite operators increases, the overcrowding of satellites can become serious.

Unfortunately, the problem of satellite collisions in geostationary orbit is already affecting satellite operations. There are several types of collision to consider (1) between two satellites, (2) between a satellite and a piece of debris, and (3) between space "junk". An operational satellite becomes a piece of debris or "junk" when it malfunctions or is no longer required.

An examination of the locations of geostationary satellites reveals regions of moderate satellite density compared to the entire geostationary ring [3,5,7].

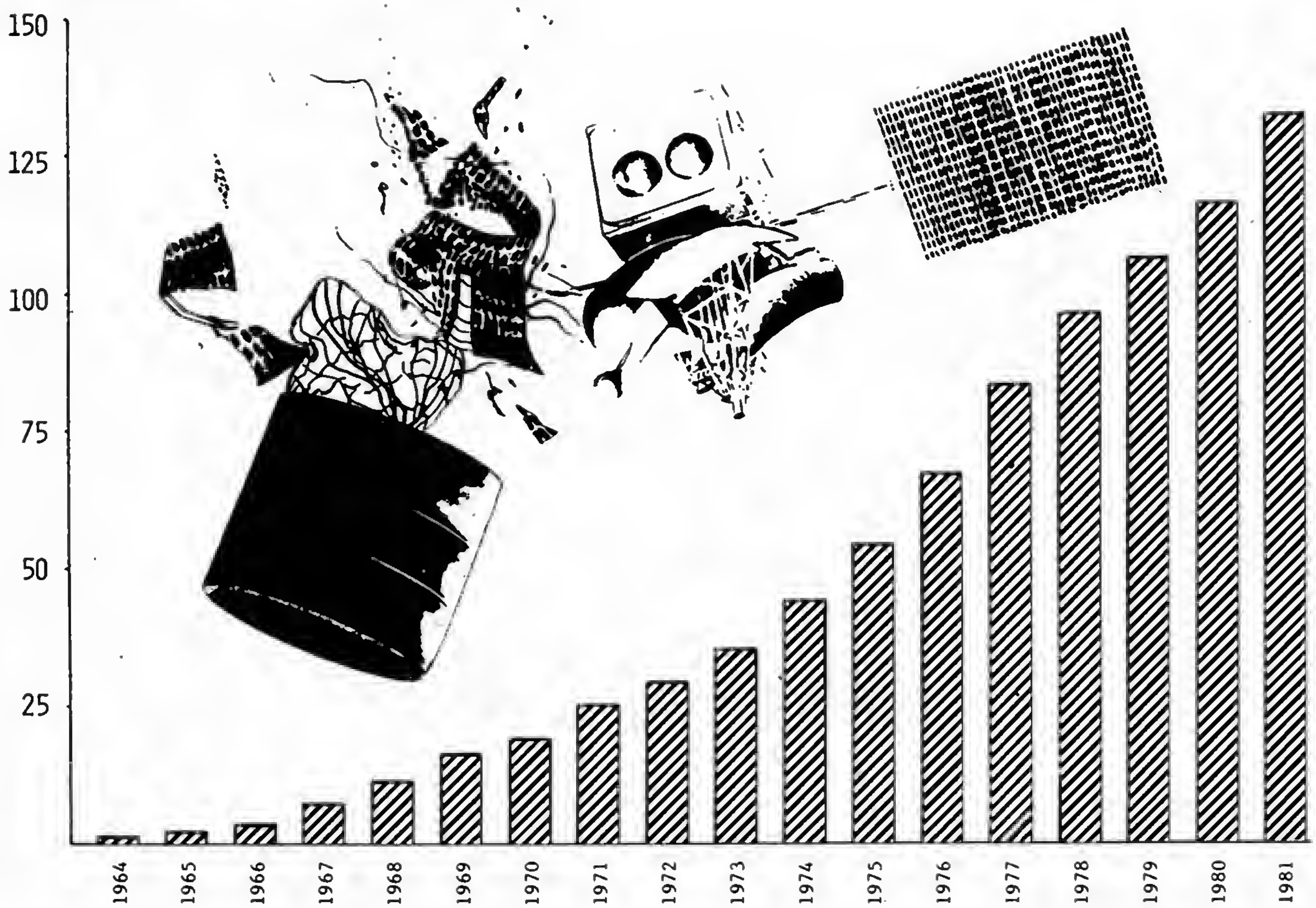
Three factors contribute to the possibility of collisions between nearby satellites. First are the effects of the Earth and luni-solar gravitational perturbations which cause all satellites to be pulled away from their initial "stations". The ellipticity of the Earth's equator is responsible for the oscillations of inactive satellites around either 75°E or 105°W longitude. Periodic station-keeping manoeuvres are required to counteract these forces but this, in turn, introduces the second factor contributing to collisions. If two satellites are close to each other, care must be taken that a normal station-keeping manoeuvre by one will not bring about a collision.

The final factor is the uncertainty with which we know the location of these satellites. The positions of rapidly-moving low altitude satellites are known fairly accurately. However, geostationary satellites are at a great distance, appear motionless over moderate periods, and can usually be seen by only one or a few tracking stations. Virtually all tracking in the geostationary orbit is done by a variety of optical trackers, which currently have several inherent limitations.

Collisions need not be explosive events. The breaking-off of a delicate solar panel or the upsetting of a carefully balanced spin axis can be immediately and irrevocably fatal.

The Satcom 3 communications satellite was lost in 1979.

RCA



Cumulative growth of geostationary satellites. This chart reflects only satellite payloads in low inclination ($i < 3°$), nearly circular, 24-hour orbits. Rocket bodies and other debris are not included. *Inset:* the collision of two satellites can produce a cloud of particles hazardous to other spacecraft.

Satellite–satellite Collisions

Three cases which took place within a two week period illustrate the problems. In early May 1980 it was estimated that 1973-40A (US OPS 6157) and 1978-16A (Fltsatcom 1) would soon pass close to each other. Specifically, on 4 May the satellites would pass within 9.4 km with an uncertainty of ± 10.0 km and on 8 May the miss distance was reduced to only 3.5 km with an uncertainty of ± 20.0 km. Although the highest probability of collision was only 1.5×10^{-7}, on 3 May Fltsatcom performed an evasive manoeuvre.

Also in this region near 100°W, was 1974-22A (Westar A). On 9 May, and again on 15 May, OPS 6157 and Westar were predicted to make close approaches. In this case neither spacecraft had any propellants left for manoeuvring, so no action (apart from the crossing of fingers!) was possible. Not too far away, near 135°W, 1979-53A (US OPS 7484) and 1978-113A (DSCS 11) were closing in on one another. Miss distances of 9.6 ± 40.7 km and 3.5 ± 40.7 km were predicted for 16 May. Reluctantly, DSCS 11 was ordered to perform a station-keeping manoeuvre on 15 May, even though the probability of collision was only 10^{-8}.

Satellite-debris Collisions

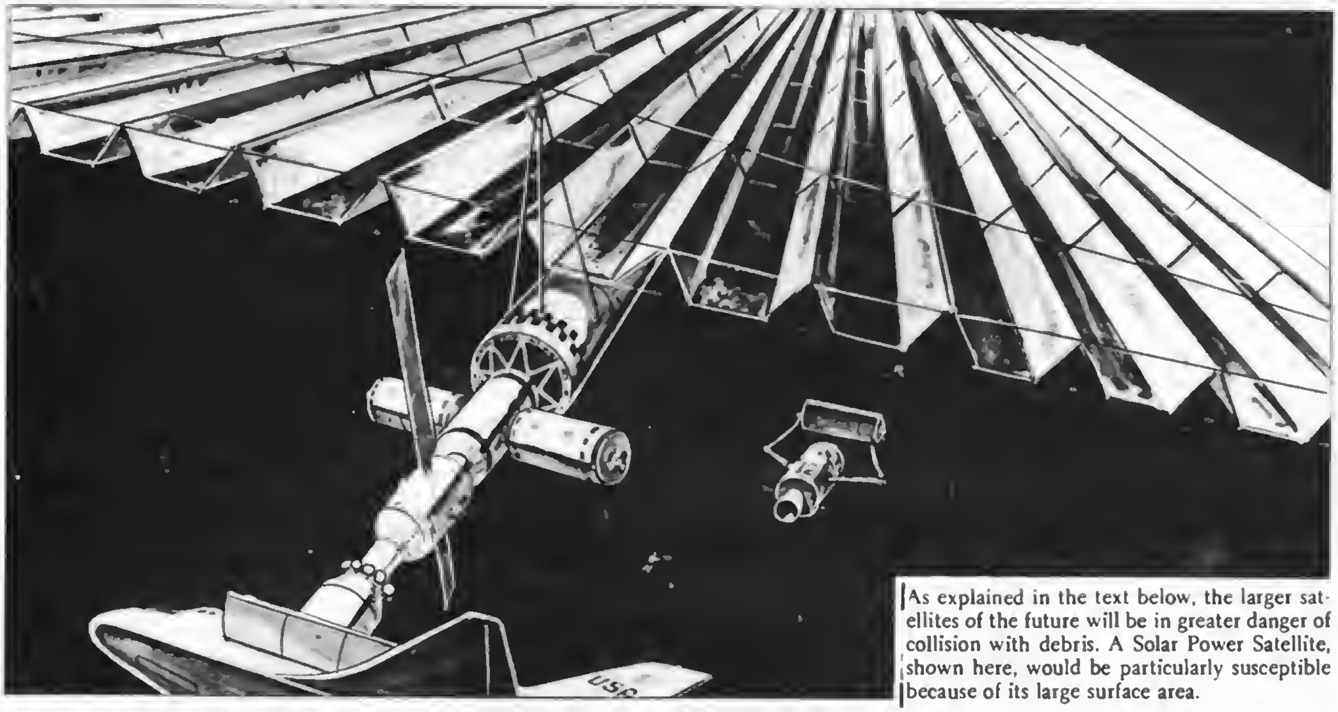
Close approaches between satellites and pieces of debris can also occur surprisingly frequently due, in part, to the large number of spent rocket stages and other discarded objects. Also, most of the debris is in orbit slightly above or below synchronous orbit so that they "walk" through the geostationary regime. Collisions between satellites and spent rocket bodies are one of the most probable since both have significant cross-sections. A little more than four months after the launch of 1979-53A (a US military satellite), it and its rocket body passed close by. Again, although the miss distance was computed to be 20.9 ± 20.9 km, the satellite was commanded to perform an evasive manoeuvre.

Not all encounters can be so easily predicted. With today's tracking devices, objects with a cross-section less than 1 m^2 are largely undetectable. Two US Air Force satellites apparently collided with small objects, shown by sudden changes in the angular momentum of the spacecraft [8]. The nature of these objects – manmade or natural – is, of course, impossible to determine.

Sources of Debris

Collisions between inactive or unseen bodies do not normally generate much excitement, but they do have to be taken into account. Collisional velocities of typical objects at geosynchronous altitudes are much smaller than the average 10 km/s collisional velocity below 2000 km altitude [1]. However, even low velocity impacts, particularly between dead satellites and rocket bodies, can produce many additional moderate-to-small fragments which, in turn, pose problems to other satellites. For low altitude satellites this important process has been assessed to be potentially self-regenerative.

An associated problem is the accidental explosion of man made objects near geosynchronous altitudes. During the apogee burn of Skynet 1B on 22 August 1970 the motor failed, possibly creating a cloud of long-lived particles in low inclination orbits



As explained in the text below, the larger satellites of the future will be in greater danger of collision with debris. A Solar Power Satellite, shown here, would be particularly susceptible because of its large surface area.

with apogees at geosynchronous altitudes. Two other spacecraft, the American RCA Satcom 3 and the Japanese ECS 2, were lost under similar circumstances in late 1979 and early 1980 [9]. They too, may have formed particle clouds capable of intercepting the geostationary orbit.

A second source of high altitude debris may come from spent US Delta rocket bodies used on geosynchronous missions. By mid-1981 at least 10 Delta second stages were known to have exploded in space. Age of the rockets at the time of explosion varies from 1 day to 35 months. As of 5 April 1981, fragments from the Delta explosions accounted for nearly 27% of all the 3904 tracked objects with orbital periods less than 225 minutes [10]. The cause of the explosions is currently believed to be the accidental mixing of residual hypergolic (ignition on contact) propellants.

As geostationary spacecraft become larger, the hazard of collisions will increase significantly. One of the reasons that probabilities of collision are still low is the relatively small cross-sections of present-day satellites. If the large Solar Power Satellites (SPS) currently being discussed are actually deployed, their 125–250 km^2 surface areas will dramatically raise their probability of collisions with foreign objects.

How can collisions be prevented? Modifications of both deployment and disposition procedures are needed to prevent irreversible contamination of the geostationary orbit. Spent transfer stages should be launched in such a way as to decay naturally in a short time [11] or deliberately manoeuvred away from geosynchronous altitudes after releasing their payloads. Transfer orbits should also be designed so that launch vehicle malfunctions (such as the collision of ECS 1 with its third stage [12]) cannot eject particles through the geostationary orbit.

Satellites should be placed into sufficiently subsynchronous or suprasynchronous orbits so that their apogee kick stages cannot pose future collision hazards. All dust covers, lens caps, etc. should be discarded before the satellite places itself into a geostationary position. Close clustering of geostationary satellites [4] should be considered only when tracking and spacecraft control capabilities have been substantially improved.

Above all, spacecraft must be removed from the geostationary orbit at the end of their useful lives. The USSR appears to have started such a procedure in 1979, followed by the US in 1981. The 500 km boost given to the meteorological satellite SMS-1 [13] should be considered as a minimum requirement in light of the current distribution of geostationary satellites.

To quote an old proverb, "An ounce of prevention is worth a pound of cure". It is not sufficient to point to the low probabilities of collision existing today and ignore the problem. Not only will these probabilities rise in the future but, as has been shown, some satellite operators take the present situation seriously enough to have already performed evasive manoeuvres.

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THE STS-5 MISSION

The Space Shuttle is scheduled to begin its operational phase on 11 November with the launch of Orbiter *Columbia* on its fifth flight. The main cargo consists of two paying passengers: the SBS and Telesat communications satellites.

Kennedy Space Center Shuttle Project Engineer Robert Sieck explained that several significant changes to the spaceship were made during the eight weeks it spent in the Orbiter Processing Facility, changing it from a development vehicle into a spacecraft designed for operational use.

"Perhaps the biggest single difference will be the added crew accommodations," said Sieck. "We have four crew members on the fifth mission, instead of only two, and we have to add seats and other provisions for them, such as communications and emergency oxygen. Besides the commander, Vance Brand, and pilot, Robert Overmyer, two mission specialists will fly: Dr. Joseph Allen and Dr. William Lenoir. They will be responsible for the deployment of the communications satellites as well as the operation of other experiments carried aboard.

Sieck said that one seat was installed on the flight deck between and to the rear of the two pilots' seats, with the other on the mid-deck. "They are foldable and will be tucked out of the way for the on-orbit portion of their mission."

Another change was the deactivation of the pilots' ejection seats. "The seats will be taken out after STS-5 as part of the major modifications to *Columbia* to be done at Rockwell International's Palmdale facility in California."

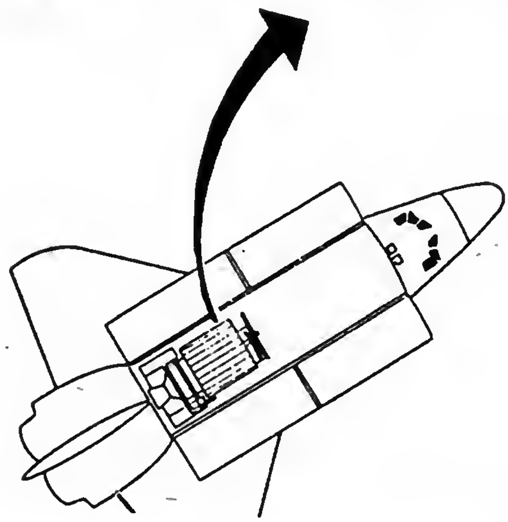
Because the STS-5 mission will be shorter than the previous two missions, Dieck said that one set of oxygen and hydrogen tanks which feed reactants to the electricity-producing fuel cells was removed, saving about 1,300 lb (600 kg) in weight.

"As another weight and cost savings measure, the ablative panels on the Orbiter's elevons will eventually be totally replaced with the reusable thermal protection tiles. About 80 tiles were bonded in position there for this next mission. Replacing the ablator with tile will save about $500,000 on each flight when that job is complete."

Other than changing ablator for tile, Sieck said that much less work was needed on the Orbiter's thermal protection system than was required following previous missions. Tiles damaged from the unexpected hail storm that pelted the Orbiter the night before the STS-4 launch in late June were repaired in place. "There were 400 tiles identified as subjects for densification. Technicians removed and densified tiles on an 'opportunity basis', but the STS-5 mission could be flown without densification of any tiles."

Another weight-saver was the removal of the 900 lb (400 kg) Remote Manipulator Arm. Sieck explained that development tests with the Canadian-built mechanical arm are complete, and engineers are satisfied with its performance. The arm is not needed on this particular flight. The two communication satellites will sit in their own cradle-like devices that have a spin-table and spring mechanism to first rotate them to about 50 revolutions-per-minute, then "pop" them into space at about 3 feet per second (1 mps).

Columbia will be some distance away from the satellite when a pre-set 45 minute timer ignites the solid propellant Payload Assist Module to push the spacecraft up to a geosynchronous altitude of about 22,300mi (36,000 km) above the Earth.



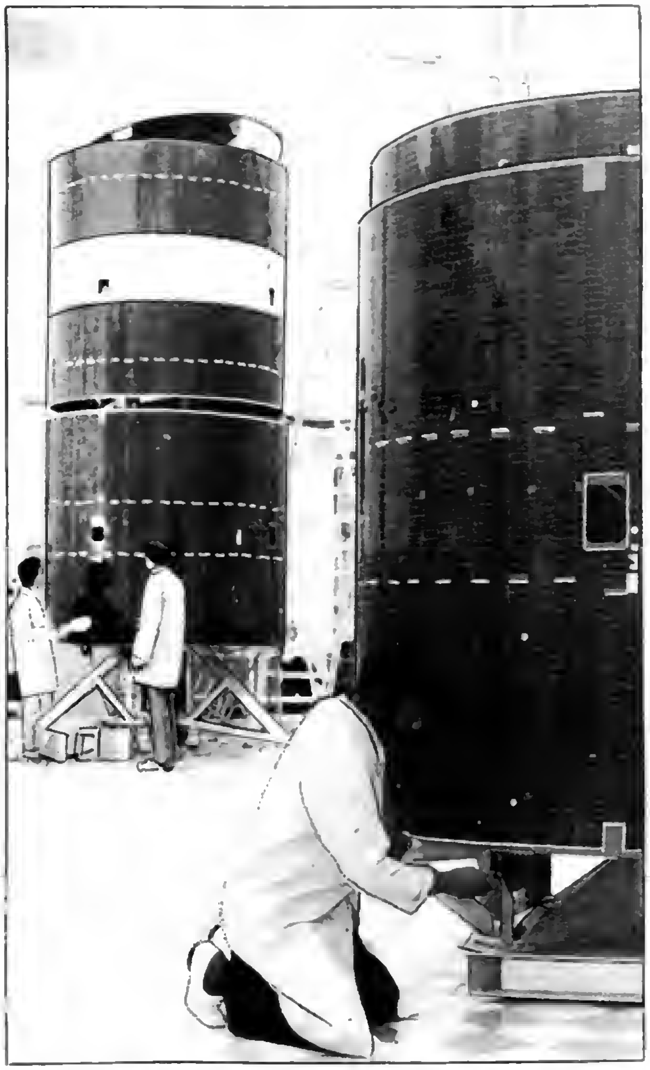
Another item removed was the 800 lb (360 kg) Induced Environmental Contamination Monitor, used extensively on flights 2, 3 and 4 to check for contaminants in and around the Orbiter's cargo bay that might adversely affect delicate experiments.

Changes were also made to the complex network of instrumentation. Some of the Development Flight Instrumentation sensors were moved to other parts of the spaceship, or made part of the Operational Instrumentation system.

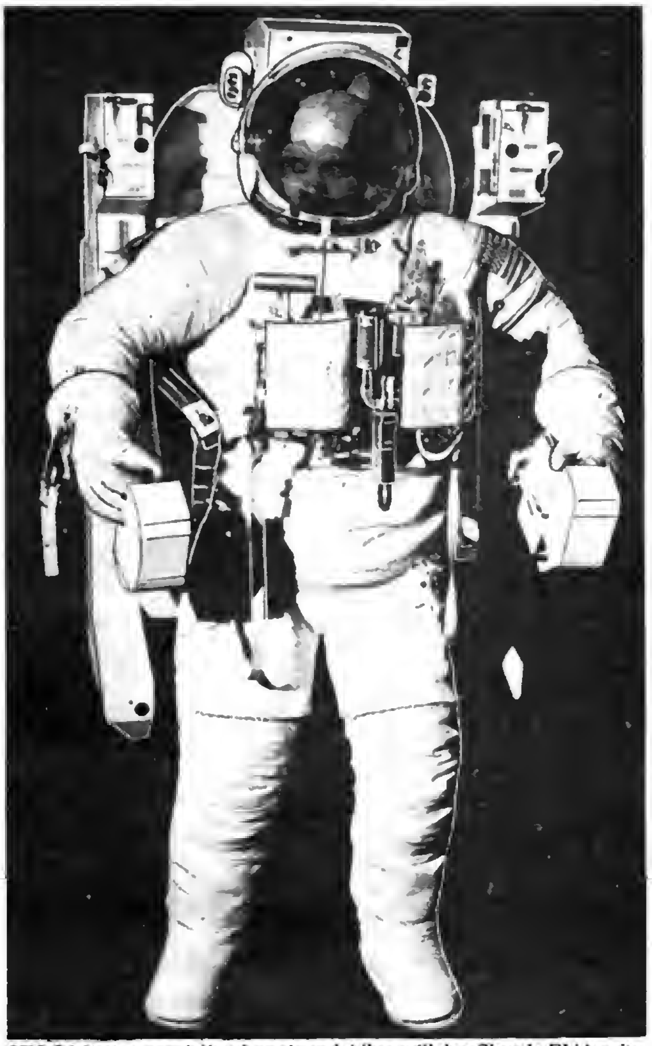
"During the post-STS-5 modification period, the entire DFI package will be removed and replaced with a compact measurement unit," Sieck said. "Changes in location of these sensors will be compatible with the new measurement system. Major changes were also required for the two commercial satellites, but with the idea that those changes will be compatible with future commercial customers as well."

Sieck said that, in order to monitor the spacecraft's vital functions, as well as being able to send commands to the satellites and their associated handling equipment, "black boxes" were installed as part of the Operational Instrumentation system. Other "black box" changes were made to improve the reliability of the flight control system.

The number of problems arising from the STS-4 flight that engineers had to fix prior to STS-5 was dramatically lower than



Checks underway on the two STS-5 commercial payloads: the Anik C-3 (background) and the SBS F-2 communications satellites. Both are of the Hughes HS-376 type (reviewed in the August/September 1981 Spaceflight, p.205) with the extending skirt of solar cells.



STS-5 Mission specialists Lenoir and Allen will don Shuttle EVA suits for a 3½ hour foray into the cargo bay. They must pre-breath pure oxygen in the cramped airlock for several hours beforehand though in order to avoid "bends" during their work in the reduced-pressure suits. The photograph shows Bruce McCandless, an astronaut since the 1960's but still without a flight, testing the EVA suit with a manoeuvring backpack.

STS-5 crew (left to right): Joseph Allen, William Lenoir, Robert Overmyer (pilot) and Vance Brand (commander). Only Brand has flown in space before but the other three have been in training since the 1960's.

All photos NASA

Not flying on STS-5 but aboard STS-7 next April: Sally Ride. She should be the third female to orbit the earth but she may well be the first selected without a view to catching headlines around the world.

NASA

on any previous flight: from about 150 items after STS-1 to only about 20 as a result of STS-4.

The major hardware changes were the removal of the No. 1 fuel cell, replacement of the No. 3 Auxiliary Power Unit and its associated Water Spray Boiler, and the changing of a thruster on the Forward Reaction Control System. The fuel cell was to be returned to its manufacturer, United Technologies, for "troubleshooting", with the possibility of it being reinstalled if it could be repaired in time. The suspicion was that there was a temperature control problem indicated by a low exhaust outlet temperature seen during STS-4.

Shortly after the June liftoff an upward firing thruster on the nose developed a small leak. Ground controllers shut off the manifold to that thruster for part of the mission. The leak appeared to stop, and the manifold was reopened for normal use of the thruster during re-entry.

"But once we were back on the ground, the thruster began to seep again," Sieck explained. "It may be temperature sensitive." The entire Forward RCS module was removed and sent to the Hypergolic Maintenance Facility where the thruster was taken out and replaced.

Engineers struggled to explain the pressure fluxuations seen on APU No. 3's lubricating oil system on the STS-4 flight. On STS-3, the Water Spray Boiler for No. 3 froze up shortly after liftoff, forcing the astronauts to shut that particular APU down early (each APU has an associated spray boiler to maintain the temperature of the oil system). Ground controllers saw a similar phenomenon on STS-4, but the boiler did not get cold enough to freeze and the APU did not have to be turned off early. Both were removed from *Columbia* and sent to the Johnson Space Center for analysis.

A "hot firing" of the new APU was scheduled to be performed at the conclusion of the tanking test on the launch pad.

The toilet was also an item of investigation. "The flight crew reported that the potty worked," said Sieck, "but the speed of the slinger [used to remove waste matter] appeared to be slower than it should have been." He said the toilet was removed and sent back to its vendor, General Electric, for analysis.

Some work also had to be done on the controller that connects the Orbiter to the Getaway Special canister.

The STS-5 payloads also include the Monodisperse Latex Reactor, and the Electrophoresis Equipment Verification Test (EEVT). The MLR, making its third trip into space, is designed to study the feasibility of making identical size latex spheres which may have major medical and industrial research applications.

The EEVT was carried on STS-3. It is designed to evaluate the feasibility of separating cells according to their surface electrical charge. Samples made during the third flight were ruined because of a failure of the freezer which preserves the degree of separation during descent.

Columbia, delivered on July 15 to Kennedy on the back of NASA's 747 Shuttle Carrier Aircraft, was processed in Bay 1 of the sophisticated hangar. Next door, in Bay 2 of the Orbiter Processing Facility, sits *Challenger*, *Columbia's* sister ship, also being readied for space flight. *Challenger's* first mission is scheduled for this January.

Columbia was towed over to the Vehicle Assembly Building in mid-September where it was mated with the two Solid Rocket Boosters and External Tank.

Various tests, including a simulated countdown with the flight crew, and a loading test of the External Tank with liquid hydrogen and oxygen were performed at the pad. The hypergolic propellants were to be loaded aboard *Columbia*, and the two communications satellites inserted in the cargo bay, prior to starting the countdown for an 11 November launch.

The five day mission is scheduled to end with a landing on the desert lakebed at Edwards Air Force Base in California. *Columbia* will then be returned to Rockwell International's Palmdale Facility in California for modifications. *Challenger* will be used while *Columbia* is being outfitted for operational duty.

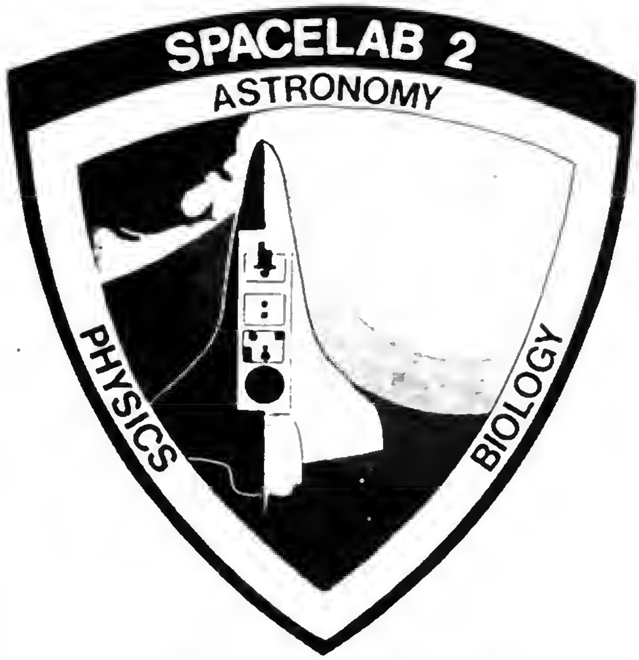
NOVA ONE YEAR IN SERVICE

The US Navy's NOVA-1 navigation satellite has now completed its first year in service. The satellite is the first of three being built by RCA under contract to the Navy's Strategic Systems Project Office. It is part of the Transit system that serves as a worldwide navigation aid for Navy and commercial ships. Transit satellites have been used for all-weather global

navigation since 1964 to support missile-carrying submarines.

Improvements in NOVA over earlier satellites include a stronger transmitter, increased computer memory, improved reference clock stability and a capability to compensate for orbit disturbances. They also require fewer position-updating transmissions from ground control stations.

The satellite weighs 367 lb (166 kg) at launch and orbits at an altitude of 600 miles (970 km). With its 26 ft (8 m) gravity gradient boom extended, it is about 33 ft (10 m) long. Power is provided by four solar panels and a 12 ampere-hour, nickel cadmium battery. The solar panels keep the battery charged for use when the satellite is in Earth's shadow.



Badge for the Spacelab 2 mission.

ESA SPACELAB TEAM

Seventeen European Space Agency (ESA) engineers are working at the Marshall Center to prepare for the first mission of Spacelab. The engineers will be based at Marshall until next spring. The ESA team will complete the final stages of its preparation for next September's Spacelab 1 mission. This will involve extensive training and simulations with Spacelab investigators and the Marshall cadre of Spacelab payload operations engineers supporting NASA experiments on the mission. Several months before the mission, the NASA/ESA team will begin supporting operations from the Payload Operations Control Center (POCC) at the Johnson Space Center.

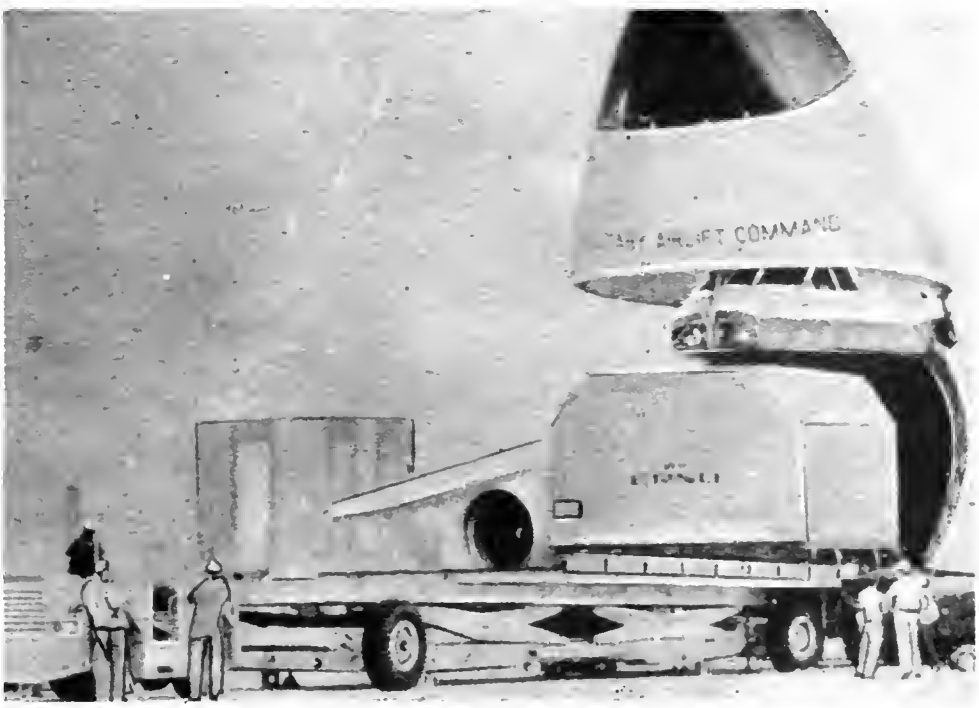
"With the mission getting near, both the Marshall POCC cadre and the ESA team are working extremely closely" said Tom Recio, Marshall's payload operations director. "We have already developed a fantastic working relationship with the dedicated and experienced team from ESA."

The ESA team has been preparing for the Spacelab mission over the past five years, according to Bob Chesson, a UK engineer and manager of ESA flight operations at Marshall. This preparation has included developing on-board computer software and displays, writing crew procedures, developing experiment simulators for training the crew and the POCC team, developing the on-board and POCC computer data bases and developing the POCC displays and procedures.

"It's difficult to realize how much effort goes into preparing such a complex scientific mission unless you're involved in the details," said Chesson. "Every procedure, every bit of data, every command has to be prepared in the exact sequence it will run during the mission and then checked thoroughly by hand and by tests with the experiment hardware and software to make sure it is right. Spacelab 1 is only a seven-day mission and mistakes could be extremely costly to the scientists."

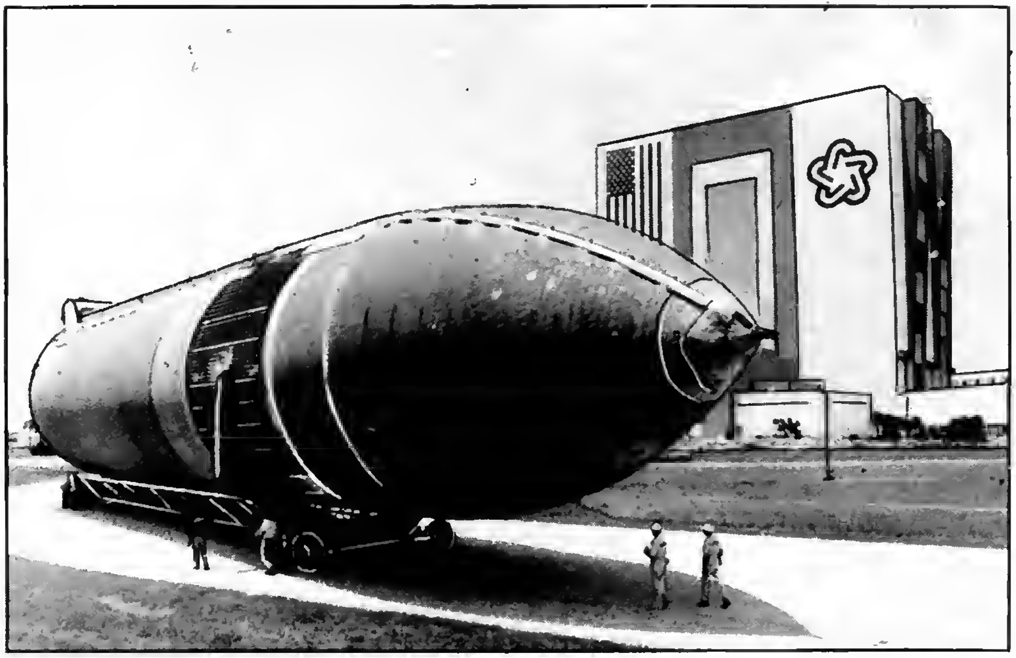
The ESA engineers represent six European nations, including Belgium, Denmark, Germany, Great Britain, Italy, and The Netherlands.

During the Spacelab 1 mission, 38 experiments from five different scientific disciplines will be conducted. The experi



Three Pallets for the Spacelab 2 mission (to be flown in 1984) arrived at the Kennedy Space Center in July. Note the Vehicle Assembley Building in the background.

NASA



The last of the heavyweight External Tanks (ET-6) for the Shuttle arrives at Kennedy Space Center. It will be used on the STS-7 mission next July after the first flight of the light-weight tanks on STS-6 (see this month's "Milestone").

NASA

ments will involve the NASA/ESA team in performing more than 9,000 experiment configuration changes: turning experiments off and on, changing power levels, etc.

The ESA engineers will support the operation of 30 ESA experiments aboard Spacelab 1 from the Payload Operations Control Center at the Johnson Space Center.

"Our task during the mission is to provide operations support to the European investigators and allow them to concentrate on their scientific investigations as well as providing the ESA experiment operations expertise needed to support the Marshall cadre of Spacelab payload operations engineers for their direction of the total mission operations," said Chesson.

SPACELAB DELIVERY

The final elements of the first set of Spacelab flight hardware were delivered in July to NASA. The elements, including three Spacelab pallets, an igloo, ground support equipment and some space parts, will be kept at the Kennedy Space Center and used to support Spacelab 2 and future missions. Spacelabs 1 will fly next September.

The first set of flight hardware was provided at no charge to NASA, but a second flight unit is being bought for approximately $300 million.

LATEST DELTA SUCCESS

The launch of the Anik-Dl communications satellite on 27 August marked the first use of the Delta 3920/Payload Assist Module combination, as well as being the 30th consecutive successful launch of the basic vehicle.

The new Delta 3920 series went into operation on 16 July with the launch of NASA's Landsat 4 Earth resources satellite from the Western Missile and Test Range at Vandenberg Air Force Base in California.

Despite the introduction of the Space Shuttle, the number of satellites awaiting launch is greater than ever. The Anik satellite was sent aloft from the newly-refurbished Pad 17B at Canaveral, the first use of the facility for four years; NASA believes that the two Delta pads will allow them to make 18 firings a year.

The Delta was first introduced in 1960 (with the unsuccessful attempt at orbiting the first Echo balloon) to satisfy the demand for a medium-payload vehicle. It has proven itself to be the world's most reliable expendable launch vehicle, with an overall success rate of 93.4 per cent, including 94.7 per cent since July 1972 and 100 per cent since 22 October 1977.

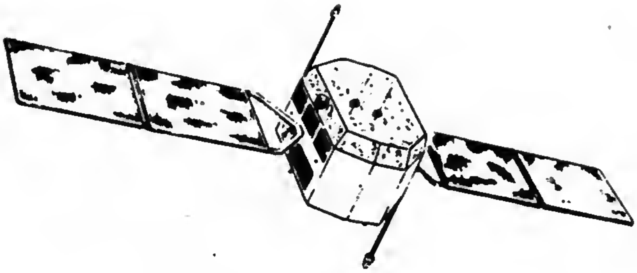
During its more than two decades of service, Delta has kept pace with satellite customers' demand for greater payload capacity and more sophisticated mission capabilities. Today's most powerful model can launch 28 times as much payload into a geosynchronous transfer orbit as the first version.

As the high volume of demand for Delta-class payload launches (both firm missions and Space Shuttle backup missions) developed for the 1980's, it became clear that the vehicle had to be kept in the intentory. The Delta 3920/PAM used in the Anik-D1 launch is one of four versions in service, each a three-stage vehicle augmented by nine solid propellant strap-on boosters. As the most powerful of these, the 3920/PAM can boost payloads of up to 2800 lb (1720 kg) to Earth-synchronous orbits 22,300 mi (35,880 km) high.

The first PAM was flown in November 1980 when Delta 153 successfully launched the SBS-1 communications satellite. Seven PAMs have now lifted payloads into geosynchronous orbit from Delta 3910s.

ESA ORBITING OBSERVATORY

One of the five European proposals being put forward as the next ESA satellite project is that of Magellan, writes Andrew Thomson. The UV astronomical observatory will be in competition with the ISO (Infrared observatory), X-80 (X-ray observatory), Disco (solar astronomy) and Kepler (Mars orbiter) proposals for selection next March. Descriptions of the last two can be found in the April and June issues of this year's *Spaceflight*.



Magellan would orbit a far-ultraviolet (UV) spectrograph to survey our own and other galaxies. The spectrograph, with high resolution and sensitivity, would cover the 500–1400 7 wavelength range. Current UV missions such as the International Ultraviolet Explorer and the Space Telescope do not venture into wavelengths shorter than 1150°. Wavelengths below that are still basically unexplored except for a very few observations of very bright objects made by the "Copernicus" Orbiting Astronomical Observatory launched ten years ago.

Magellan is a revised version of the MISIC (Milieu Interstellaire et Intergalactique) instrument originally proposed by French and American groups within the framework of the Space Shuttle programme. With the shuttle delays, laboratory studies of the instrumentation were continued, indicating that a free-flying satellite was timely.

The observatory is designed to cover a wide range of subjects: the composition and behaviour of interstellar matter (in our own and other galaxies); the chromospheres and coronae of stars; binary star systems, and star clusters; stellar mass loss; galactic nuclei and quasars; intergalactic matter; and planetary physics.

Magellan can be expected to contribute significantly to our understanding of the evolution of galaxies. Matter is cycled continuously from the interstellar medium to stars, and back again via mass loss and explosions. Magellan will observe the state of this matter during most of its phases: inside the interstellar medium, in the atmospheres of stars, in stellar winds and ejecta, and even at the surface of stellar remnants such as white dwarfs and, possibly, neutron stars.

The satellite would be placed into a highly eccentric (1000×71,000 km) 24-hr orbit following launch by an Ariane 2 or 3. Total payload mass would be in the 200 kg range, the whole spacecraft weighing approximately 700 kg (fully fuelled). It would be designed for a lifetime of two years, although it could observe the full celestial sphere within six months.

ROSAT AGREEMENT

A memorandum of understanding was signed on 8 August in Vienna by James Beggs, NASA Administrator, and Hans-Hilger Haunschild, State Secretary of the German Federal Ministry for Research and Technology (BMFT), to establish cooperation on the Roentgensatellit (ROSAT) X-ray observatory. ROSAT is scheduled to be launched by the Shuttle in 1987.

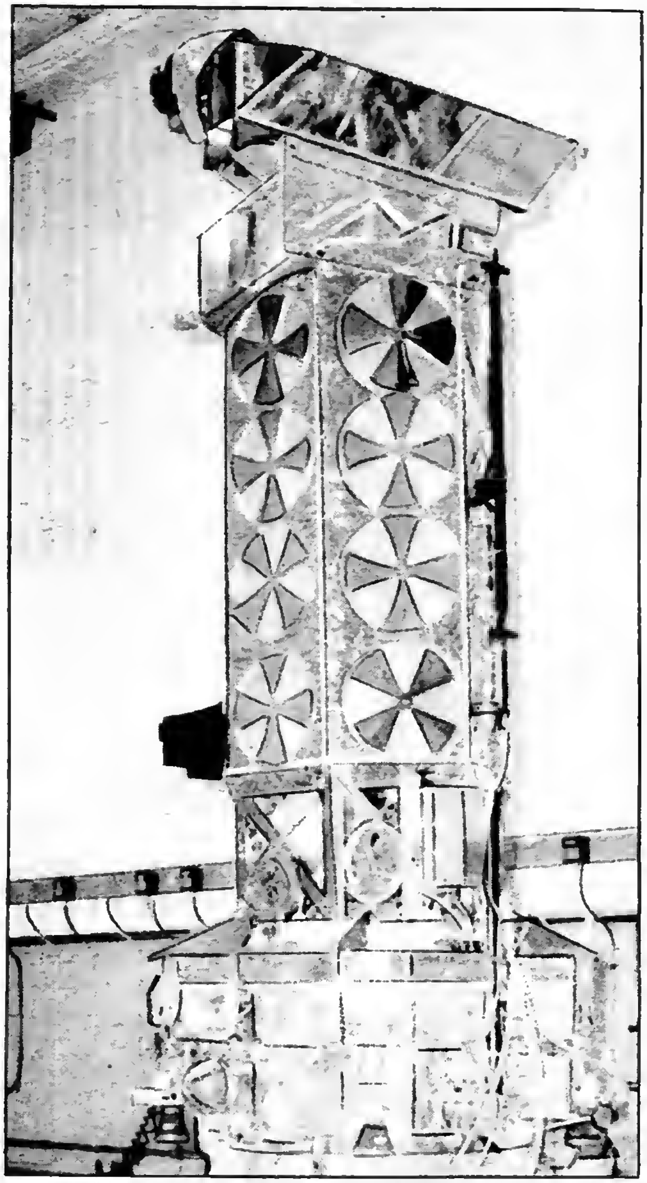
ROSAT will study X-ray emissions from non-solar celestial objects, surveying the sky for X-ray sources and pointing at specific sources for extended periods.

The satellite's main instrument will consist of a Wolter type I X-ray telescope with a carousel focal plane assembly carrying two imaging proportional counters and one high resolution imaging detector. The main telescope will be supplemented by an Extreme Ultraviolet wide field camera oriented parallel to it.

BMFT will provide the spacecraft and the X-ray telescope and NASA will provide a high resolution imaging detector and Space Shuttle launch services. The UK Science and Engineering Research Council will provide the Extreme Ultraviolet wide field camera. BMFT will compile an X-ray source catalogue from the data obtained during the survey portion of the mission. NASA and BMFT will each invite proposals from the scientific community to carry out investigations during the pointing phase.

U-2 LIGHTNING EXPERIMENT

An experiment designed to help in the development of a sensor system to "map" lightning from space was flown aboard a NASA U-2 aircraft in August. According to Hugh Christian, project scientist at Marshall Space Flight Center's Space Sciences Laboratory, the Optical Lightning Detection Experi-



The first of the advanced Tiros-N/NOAA meteorological satellites (see news story on p.357 of the September/October *Spaceflight*) is due for launch next February. The satellite, here undergoing optical alignment at RCA Astro-Electronics' base in New Jersey, will also carry Search and Rescue beacon relay equipment to locate crashed aircraft and ships in distress.

RCA

ment measures the optical "signatures" of lightning from thunderstorms.

This experiment complements the Nighttime/Daytime Optical Survey of Lightning which was taken into space on the second and fourth flights of the Space Shuttle to provide a wide field of view from orbit (see p. 414 of the last issue). The U-2 flight allowed the use of more sensors, larger cameras and a longer duration over a single storm system. This was the seventh in a series of flights over the tops of thunderstorms to look at the relationship between storm severity and lightning activity, how lightning rates correspond to cloud top motions and to measure the amount of lightning occurring in severe storm systems. "The measurements are necessary for the development of a lightning mapper which could enhance our knowledge of lightning-related weather phenomenon once it is installed in a geostationary weather satellite," said Christian.

The major problem which must be solved before such a mapper could be installed in such a satellite is detecting the lightning in the daytime. Light reflecting off the tops of the clouds is brighter than the lightning emissions. Several approaches to filtering the light in order to detect the weaker flashes are being studied. Large amounts of lightning may provide immediate indications of a severe storm before long-range radar would otherwise indicate it.

ASTROBABY

Rhea Seddon Gibson, NASA astronaut, has given birth to a 3.2 kg baby boy in Clear Lake Hospital, near the Johnson Space Center in Houston. The baby, born in July, developed slight breathing trouble and was subsequently transferred to another hospital, although a NASA official revealed that it was not a serious problem. Rhea Seddon married fellow Group 8 astronaut Robert Gibson in May 1981; neither has yet made a space flight, writes Dave Shayler.

Another Group 8 astronaut, Shannon Lucid, had three children before entering the space programme, and Soviet cosmonaut Valentina Tereshkova gave birth to a daughter in 1964 after her flight in 1963.

The Gibsons have named their new son Paul Seddon Gibson.

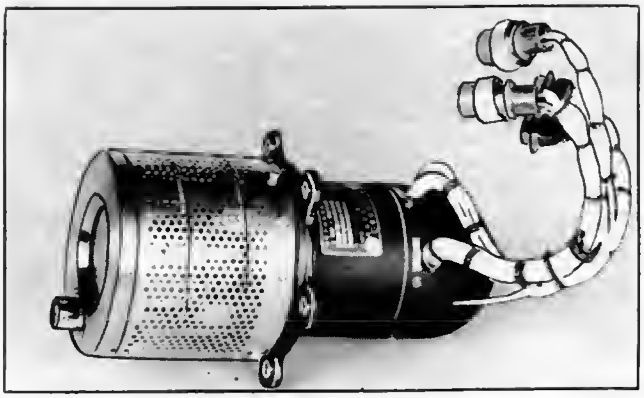
RHYTHM RESEARCH

Scientists at NASA's Ames Research Center in California are studying the body's circadian (24-hour) rhythms to prepare for extended space missions. Small groups of people will be subjected to weightlessness, rapid shifts in light/dark "cues" and social isolation. All three of these conditions have been found to be sufficient to disrupt daily rhythms.

Understanding the effects of these conditions is important because such conditions on Earth are associated with boredom, irritability, negative moods and withdrawal. Circadian desynchronosis (upsetting of the 24-hour rhythms) may also cause fatigue, decreased performance, insomnia, anxiety, gastrointestinal and other physical symptoms.

On Earth most humans maintain a basic 24-hour cycle, undisturbed until a crossing of time zones ("jet lag"), an alteration of work hours or a late night disrupts the cycle. Upset rhythms then cause problems with physical health, emotions, behaviour, sleep, altered responses to medication and decreased performance. Many people are more susceptible to colds, viruses and infections when their rhythms are disrupted and headaches and intestinal disturbances are more common.

These rhythms are linked to the light/dark cycle of the Earth. They appear to be a natural function of cell-formation cycles in the body; cancer cells are the only cells which do not exhibit rhythms.



This 2 mN (Specific Impulse 2200 s) ion thruster is presently undergoing tests aboard Japan's ETS-3 satellite, launched in August, as a station-keeping thruster.

NASDA

DOD ASTRONAUTS

It has recently been revealed that the US Department of Defense elected a group of 12 USAF and one USN Officers (mostly Captains and Majors) in late 1980 to assist in the preparation and development of DoD payloads planned for launch by the Shuttle.

Seven of the group participated in a series of tests in the neutral buoyancy simulator at the Marshall Space Flight Center in Huntsville. It is expected that some will be selected as Mission or Payload Specialists for DoD Shuttle missions, writes Dave Shayler.

No biographical details on the 13 have been released, and it is not clear if any information on later military Shuttle crew personnel other than NASA astronauts will be released before each mission.

According to the latest information on the 13 DoD Manned Spaceflight Engineers (MSE), as they are designated, is that a group was to have been selected in the summer of 1982 for a one year training programme, beginning in 1983, to prepare for space flights from 1984 onwards.

IN THE PAST

25 Years Ago ...
6 December 1957. Vanguard TV-3 explodes on the launch pad during the first attempt at placing a US satellite in orbit.

20 Years Ago ...
4 December 1962. The first test of the Apollo main parachute system is conducted in California.

15 Years Ago ...
17 November 1967. Eight days after landing on the Moon, Surveyor 6 reignites its vernier motors to move some 10 ft (3 m) across the surface.

10 Years Ago ...
7-19 December 1972. Astronauts Cernan, Schmitt and Evans fly the Apollo 17 mission to Taurus-Littrow, the final landing of the Apollo project.

5 Years Ago ...
25 November 1977. The BIS announces completion of the Daedalus star probe study, the end of some 10,000 man-hours of work.

D.J. SHAYLER

THE DECLINE AND FALL OF SETI

By Robert Sheaffer

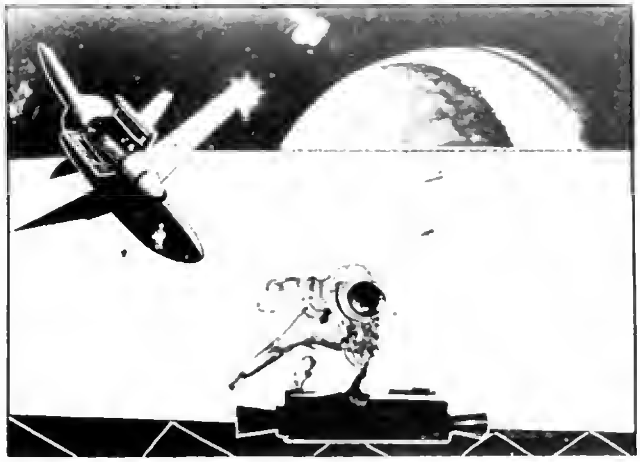
Introduction

NASA's 1978 proposal for a $2 million Search for Extraterrestrial Intelligence (SETI) programme, to begin in fiscal year 1979, received a good deal of publicity at the time. The programme, if approved, would have risen in cost in succeeding years, but it ran into trouble in the US Senate, where it was defeated by the Chairman of the Senate Appropriations Committee, William Proxmire. Proxmire had earlier given NASA his celebrated "Golden Fleece" award for SETI, signifying that it was, in his opinion, the "biggest, most ironic, or most ridiculous example of wasteful spending for the month."

Most people believed, Proxmire among them, that NASA's SETI activities ended when Congress refused to appropriate funds for SETI. In fact, the NASA team continued its activities, *albeit* at a reduced pace, with hardware being prepared for use on radio telescopes under NASA sponsorship.

NASA held a meeting of its SETI Advisory Panel in Washington, D.C. in May 1976. At that time, no information had been published about NASA's SETI interest. The panel members included some of the best-known SETI theorists and researchers, such as Carl Sagan, Frank Drake, Bernard Oliver, John Billingham, and Sebastian von Hoerner. Various SETI approaches and programmes were considered at the day-long meeting, including Project Cyclops (a gargantuan array of thousands of radio telescopes), a kilometre-sized radio dish in orbit, and even an apparently serious proposal to build Project Cyclops on the far side of the Moon! (See Robert Sheaffer's "NASA Contemplates Radio Search for Extra-terrestrial Intelligence" in the October 1976 issue of *Spaceflight*—Ed.)

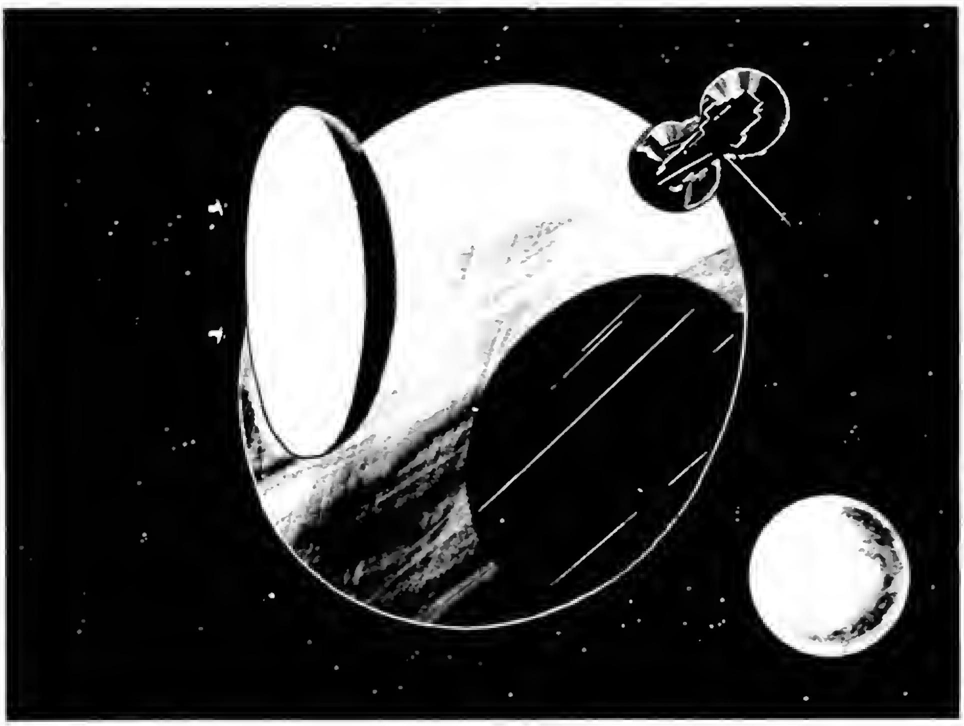
At this meeting NASA was extremely concerned about getting too much publicity about SETI. No mention was made of the meeting to the public, except for the necessary inclusion in the Federal Register, which is so massive that it is almost impossible to find anything in it. NASA officials voiced their concern that some reporters for a sensationalist newspaper might get word of the plans prematurely, generating unsavoury publicity. Since 1976 was an election year, it was decided that no public announcement of the plan would be made until at least after the election. In any case, the different SETI approaches had not yet been fully evaluated. Concern was also expressed that NASA might be given the "Gold Fleece" for SETI which, of course, they eventually were after the plan was made public in 1978.



Maintenance of the SETI antenna illustrated at the bottom of this page (1976 NASA proposal). NASA

SETI Goes Underground

By 1980, after the defeat of SETI in Congress, everyone believed NASA's SETI programme to be dead. Everyone, that is, except a number of professional astronomers, aerospace researchers and the like who were aware of the continuing level of effort, hidden in an expenditure for "exobiology".



A proposed kilometre-sized SETI antenna in Earth orbit at a Lagrange point. NASA

The 300-ft (91m) diameter radio telescope (left, foreground) of the National Radio Astronomy Observatory in West Virginia has been used in several SETI programmes.

SETI no longer appeared as such in the NASA budget and hence it was invisible to Congress. SETI remained alive within NASA nonetheless. NASA was actually building a multi-channel spectral analyser (MCSA), capable of searching 8 million channels, each with a bandwidth as narrow as one hertz. There is no known natural object that emits radio signals of such a narrow bandwidth, the principal use of such a device being to search for artificial signals.

Requests for SETI-related documents from NASA under the Freedom of Information Act produced very little, but it became clear that $500,000 had been spent on SETI in 1980, rising to $1 million in 1981.

On 30 July 1981 the Senate was discussing the Federal budget for the 1982 fiscal year, which was to begin on 1 October that year. Senator Proxmire proposed an amendment to the NASA appropriation to read as follows: "Provided - That none of these funds shall be used to support the definition and development of techniques to analyze extra-terrestrial radio signals for patterns that may be generated by intelligent sources." Proxmire took the floor, and made the following comments:

"Mr. President, 3 years ago, NASA requested $2 million for a programme titled "Search for Extra-terrestrial Intelligence" - SETI for short. The idea was that they are going to try to find intelligence outside the Solar System. Our best scientists say that that intelligent life would have to be beyond our galaxy. (*Note:* of course this is not true. He probably meant to say "Solar System", not "galaxy".) At any rate, this $2 million would have funded the initiation of an all-sky, all-frequency search for radio signals from intelligent extra-terrestrial life using existing antennas of the Deep Space Network at Coldstone, California, and some state-of-the-art hardware that was to be developed specifically for the programme. The total cost of the programme was to be $15 million over seven years.

"These funds were stricken from the fiscal year 1979 ... appropriation bill a few months after I gave NASA a "Golden Fleece" for the proposed project, which I thought should be postponed for a few million light-years (sic).

"I have since discovered that the project has been continued at a subsistence level despite our decision to delete these funds three years ago. In 1980 NASA spent $500,000 on the project. The 1981 budget was $1 million. NASA plans to spend an additional $1 million in 1982.

"Mr. President, clearly the Congress intended to stop this research back in 1978 when it terminated funding for the programme. However, NASA has quietly continued the work under its exobiology programme.

"Why should we stop this programme, Mr. President? First, if NASA launches a full scale SETI programme the total cost will be at least $50.9 million over 10 years.

"Second, there is an excellent chance that extra-terrestrial intelligent beings do not exist. If intelligent beings did exist elsewhere and possessed the technology for interstellar communication they would have developed interstellar travel and thus would already be present in our Solar System. Certainly there is not a scintilla of evidence that life exists beyond our Solar System.

"Third, even if a radio message had been beamed to our planet from some distant civilization, it could well have originated well over a million years ago. The Earth itself is 4½ billion years old while some solar systems are even older and millions of light-years from Earth. Thus the intelligent life that sent the message might well be extinct by the time we received it or, certainly, by the time we responded. Communication over such great distances is almost meaningless."

Both Democrats and Republicans alike were persuaded by Proxmire's arguments, and the amendment was approved by the full Senate in a voice vote. The House of Representatives concurred, and the 1982 budget, with a provision specifically forbidding expenditures for SETI, was signed by President Reagan. The SETI programme could not go underground once again. This time it was truly dead, with a wooden stake in its heart.

On 30 September 1981, the last day of the 1981 fiscal year, Associated Press carried a short item entitled "U.S. Pulling the Plug on Outer Space Calls." It began, "If there are any outer space civilizations trying to contact Earth, they have until midnight tonight to get their message through."

Conclusions

NASA officials had manoeuvred themselves into an unenviable situation; in order for SETI to survive it had to be kept hidden from the public, and especially from Congress. When the scope and outline of the continuing SETI programme was revealed the Congress quickly killed it, Republicans and Democrats acting together. No unclassified scientific project can possibly exist for long in such an environment, especially one pertaining to a subject in which there is such a great public interest. Sooner or later, word was bound to leak out that NASA had buried, but not killed, its SETI programme. Apparently NASA's hope was to present the Congress with a *fait accompli*, and possibly even produce some useful scientific information before word leaked out. It might then have been more difficult to cut out.

While NASA would now seem to be out of SETI for a long time, there is nothing to prevent any private foundation, university or other institution from funding such research. It is also possible for the National Science Foundation to fund SETI, should it deem that it is a worthwhile expenditure. It is even possible for NASA to get back into SETI, this time through the "front door", if it can convince a majority in Congress that SETI is a worthwhile scientific undertaking.

SPACE COMMUNICATIONS

SEARCH AND RESCUE

The Soviet Union has launched the first search-and-rescue transponder of its COSPAS system on the Cosmos 1383 navigational satellite, orbited on 1 July from Plesetsk. Called an Emergency Position Indicating Radio Beacon (EPIRB), the device is one of two planned by the USSR in its COSPAS system trial, writes Joel Powell. Operating at frequencies of 406 MHz and 121.5 MHz with radiated power of 5 and 0.075 watts, respectively, the system is fully compatible with the Canada-US-France SARSAT system. The beacons are designed to receive distress signals from downed aircraft, relaying them to a rescue coordination station back on Earth.

The Soviets, as well as the US, Germany, the UK and Norway-ESA, plan to mount EPIRBs on Inmarsat spacecraft located in Clarke orbits to cover most of the Earth's surface. Each transponder would be fully compatible and would use frequencies of 1645.5–1646.5 MHz. Japan plans to operate a separate system using their own geostationary communications satellites. The Clarke orbit transponders are specially designed to include maritime rescue operations excluded from the EPIRB/SARSAT trials. Operations are expected to get under way as early as 1983 on Inmarsat.

SATELLITE BATTERIES

INTELSAT (International Telecommunication Satellite organisation) has awarded Harwell's Advanced Battery Project of the UK a major contract to develop improved components for satellite batteries. The 2½ year programme will concentrate on the development of nickel electrodes and synthetic separator components for nickel hydrogen battery cells. The ultimate aim is the development of Ni/H_2 batteries with increased power and reliability capable of operating in orbit for 10 years.

Ni/H_2 batteries have begun to replace nickel cadmium batteries in communications satellites, where they provide power when solar cells are inoperable during eclipse conditions and supplementary power during the daily cycle. Eclipses, which occur for two 45 day periods each year for geostationary satellites, are critical to battery life expectancy and involve severe cyclic discharging of up to 80 per cent of battery charge. A problem associated with this "deep discharge cycling" is the expansion of the positive electrodes and a change in their micropore structure resulting in a redistribution or loss of electrolyte and battery failure.

The Advanced Battery and Applied Electrochemistry Project at Harwell is one of the UK's leading organisations in the development of high energy density batteries for remote power, transport and energy storage systems.

TELESAT AGREEMENT

On 30 June the Canadian Communications Minister announced that approval had been granted to Telesat Canada for its contract to provide Argo Communications Corporation, a US satellite carrier, with six channels on the Anik D satellite, then scheduled for launch on 12 August.

This contract was signed by Telesat in accordance with an inter-governmental arrangement between Canadian and US authorities concluded in 1972, writes Gerald Borrowman. The Communications Minister said, "This is an excellent illustration of the ability of Canada and the United States to cooperate in the field of communications."

The Minister said that he was satisfied that Telesat Canada has sufficient satellite capacity to supply the services and that Telesat's present and future Canadian customers are adequately protected.

1986 will see the first use of the next generation of Intelsat satellites: the 6 series. Designed for launch by either the Shuttle or Ariane, these 4000 lb (1800 kg) satellites will each be able to handle 33,000 telephone conversations and four TV broadcasts simultaneously. The technology is based on the Hughes HS-376 and the HS-381 Leasat widebody satellites (see recent "Space Communications" for descriptions of both types).

Hughes Space & Comms. Groups

THE MAIDEN VOYAGE OF "COLUMBIA"

PART THREE

By John A. Pfannerstill

Concluded from the July/August issue.

Second Night in Space

Astronauts John Young and Robert Crippen slept much more soundly during their second night in space than they did on the first. They dropped off to sleep rapidly and, as Crippen said later, were "really sawing the Z's" when a systems alarm roused them shortly after 04:00 on 14 April. (All times are quoted in GMT unless otherwise stated.)

The alarm was associated with a low-temperature indication on one of *Columbia's* three Auxilliary Power Units (APU). They solved the problem by cycling a heater switch to get the temperature back to normal. The crew went back to sleep.

As on the day before, Young and Crippen were up and around ahead of schedule. While over Madrid at 08:11 on orbit 30, Mission Control Center-Houston (MCC-H) received telemetry indications that the food warmers had been activated and that the computer displays were running, meaning that at least one of the crewmen was awake. Since the astronauts still had about 40 minutes of sleep coming to them, flight director Neil Hutchinson elected not to have capcom Dan Brandenstein call them just then.

Up in *Columbia*, Young was making breakfast, an unusual job for him, since Crippen normally took care of the "cooking". Young had hot coffee waiting for his pilot when he woke up.

The astronauts found a teleprinter message down in the mid-deck area giving a systems status on their spacecraft and the weather forecast for their landing site at Edwards Air Force Base in California. The weather predictions were excellent clear skies, warm temperatures and little wind.

Final Day in Orbit

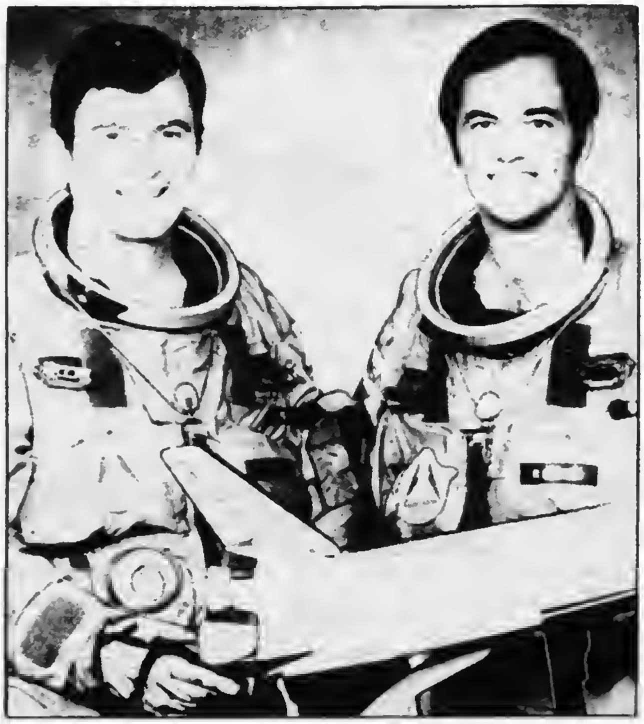
The astronauts received their first call of the day at 08:41 over Quito in Ecuador on the 31st orbit. After some wake-up music, Capcom Brandenstein informed them that the temperature in APU-2, the same unit that roused them during the night, was again dropping.

The main cause for concern was that if the unit became too cold, it might prove difficult or impossible to start, much like a car engine on a cold winter day.

Since the units supply hydraulic fluid to drive the Orbiter's aerodynamic control surfaces, they are vitally important during reentry and landing. Without them, there would be no way to control the spacecraft. Two units are sufficient to fly a normal reentry, so if APU-2 failed to start, the situation would not necessarily be dangerous. The temperature eventually stabilized at about 180°F (82°C). This was much colder than normal but the units had been test-started on the ground at lower temperatures.

Table 1 STS-1 Flight plan activities for mission day 3.

GMT	MET (DY/HR:MN)	ORBIT	EVENT
08:50	01/20:50	31	End sleep period
10:00	01/22:00	31	IMU Alignment
10:15	01/22:15	31	RCS Jet Test
10:25	01/22:25	32	Meal period
11:30	01/23:30	32	Begin entry stowage
11:55	01/23:55	33	FCS Checkout
13:05	02/01:05	33	Crew systems deactivation
13:25	02/01:25	34	EES Donning
14:30	02/02:30	34	PLBD Closing
15:15	02/03:15	35	Snack period
16:00	02/04:00	35	IMU Alignment
16:30	02/04:30	36	Seat Ingress
17:28	02/05:28	36	Deorbit Ignition
17:56	02/05:56	37	Entry Interface
18:28	02/06:28	37	Landing



John Young (left) and Robert Crippen, crew of the first Shuttle orbital flight. Young will fly the STS-9/Spacelab 1 mission in September and Crippen will commmand STS-7.

NASA

Entry Preparations

After awakening and getting the flight deck powered up, the astronauts began preparing *Columbia* for reentry. Young performed an Inertial Measurement Unit alignment at about 09:45 while over Australia, and after that, the astronauts ran a series of test firings of their Reaction Control System jets.

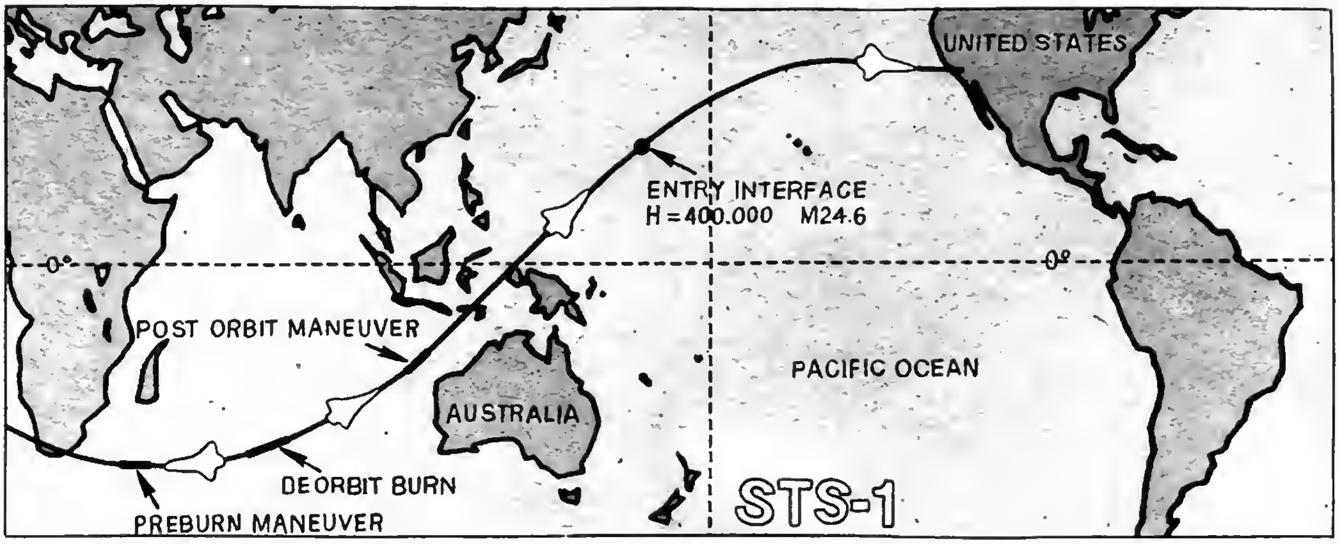
While the thruster tests were underway, members of flight director Don Puddy's Crimson flight control team began arriving in the Houston control room. Their shift would be the final one of the mission, and they listened as Brandenstein bade the crew farewell on behalf of off-going flight director Hutchinson's team.

"This is the last pass of STS-1 for the Silver team," he said as *Columbia* approached loss of signal with Madrid at 10:40, "You guys sure gave us a thrill on that launch and we really enjoyed working with you the rest of the hop. I hope that you have a safe flight home and we will see you tonight."

"Well that is mighty kind of you, Dan," Crippen responded, "The Silver team really done it. You guys do good work."

With that, the responsibilities of Hutchinson's team ended, and Young and Crippen were greeted at the next ground station by the cheerful voice of the Crimson team capcom, scientist-astronaut Joe Allen.

"We're looking forward to today," he told them, "we under-



stand that this is not a simulation today."

"I hope you're right," Young said.

After years of work and months of practising simulated Shuttle landings [1], Young and Crippen were indeed going to try the real thing.

Control System Checkout

One of their more important tasks was to perform a final checkout of the Flight Control System. The test involved movement checks on all of the Orbiter's aerodynamic control surfaces, and verification of the proper operation of all the associated cockpit avionics. *Columbia's* computers were loaded with a software package known as "OPS-8" for this testing.

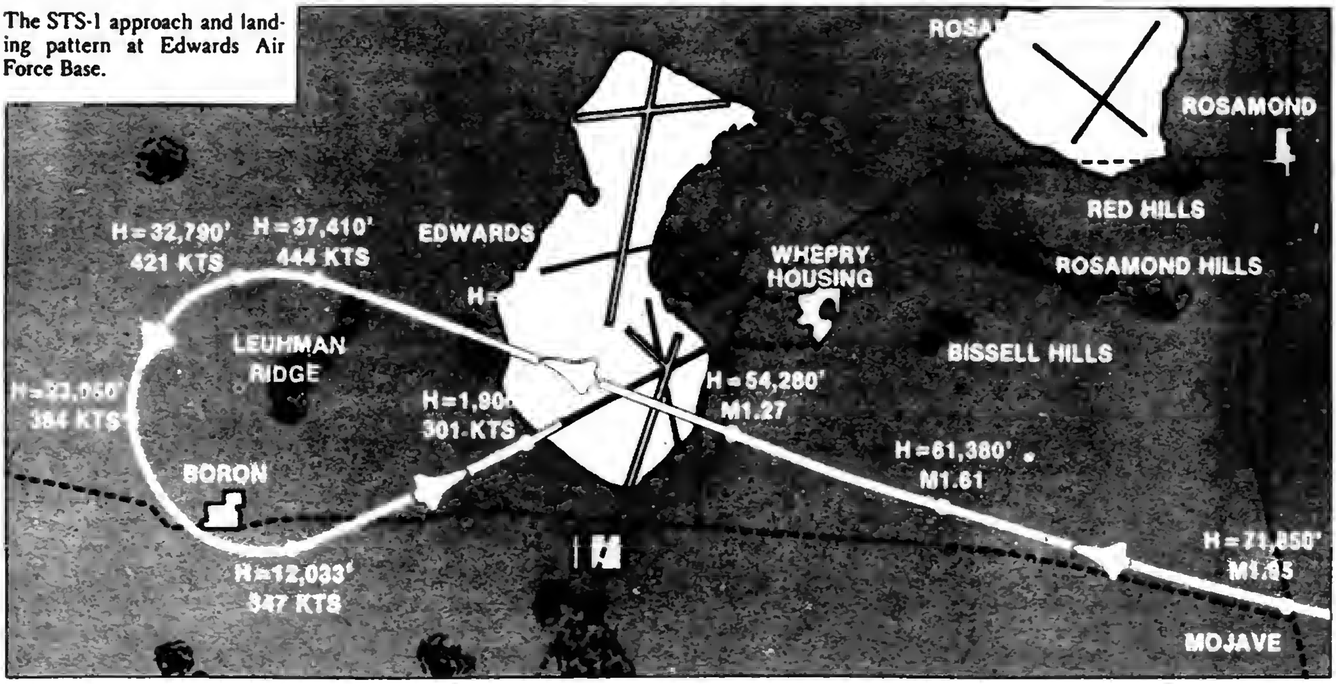
The OPS-8 load was designed specifically as a diagnostic and self-checking package to enable on-board systems operation to be evaluated without help from the ground. Nevertheless, the operation was still conducted during the Orbiter's 33rd pass across the United States to allow Houston to keep an eye on things *via* telemetry.

The tests showed that all systems were ready for the reentry. In fact, the astronauts found that the Horizontal Situation Indicator on Young's side of the cockpit, which had not been working properly earlier in the flight, was once again in order.

Among the malfunctioning systems being studied from the ground was the trouble-plagued Development Flight Instrumentation Pulse-Code Modulation recorder [2]. After the attempted changing of the recorder had proved unsuccessful the previous night, engineers began re-evaluating the possibility of having the astronauts start the recorder before strapping themselves into their seats. Revised data indicated that the tape supply might be enough to last until landing. With no better plan in mind, that was what Houston eventually decided to do. The astronauts were not immediately told of the plan, however, for they were busy activating and checking out many of the systems that would be required for reentry.

When *Columbia* came up on the US west coast at 13:20 on orbit 34, the payload bay television cameras were running, providing viewers with the last real-time TV of the mission.

The STS-1 approach and landing pattern at Edwards Air Force Base.



The cameras were being controlled from Houston by the Integrated Communications Officer Ed Fendell [3]. The astronauts continued their entry preparations while the flight controllers enjoyed beautiful vistas of the Earth.

During this pass across the States, Joe Allen gave Young and Crippen a GO for Payload Bay Door closing. But before this all-important event could take place, they had to put on their rust-coloured Emergency Ejection Suits. The men helped each other as *Columbia* passed across the Atlantic Ocean, Africa and the Indian Ocean. By the time the Orbiter had reached the west coast of Australia, the men were ready to begin closing the bay doors.

Payload Door

"Joe, do I understand that we have a GO for payload bay door closing?" Crippen asked over Yarragadee at 14:21. Allen assured him that they did, and almost immediately Crippen reported that the radiators inside the doors were stowed. The port door was closed several minutes later while over the Orroral Valley station, and the starboard door was closed sometime after losing contact with that station at 14:30.

At about the same time, the crew "dumped" the memories of their five General Purpose Computers so that engineers on the ground could verify the information stored in them was good. There was no reason to suspect any problems (the computers had functioned flawlessly so far) but the computers play a crucial role in the reentry and landing. The cross-check was being done just to make certain everything would be ready.

When *Columbia* arrived within range of Hawaii at 14:45, both the ground and the crew were able to verify that both bay doors were properly closed and latched, and Crippen reported that there had been no problems with the operation. Likewise, the computer memory checkout had gone well, and Allen was soon able to report to the astronauts that the memories were all in excellent shape.

The astronauts had been extremely busy all morning. At one point, Crippen thanked Allen for not talking to them too much while they were trying to work. "Running around this vehicle getting it ready to go takes a lot of time," he said, "and to have to stop and talk kind of slows you down a little bit."

Young agreed, "Yeah, we found out we never quite practised everything in the simulator even though we think we do."

Final Preparations

Most of the 35th orbit was very quiet. After a light snack, Young performed the final Inertial Measurement Unit alignment at 15:45 and, after that, the star tracker doors were closed to protect the instruments from the heat of reentry. By the time Crippen performed the final fuel cell purge over Australia at 16:00, the astronauts were running about 20 minutes ahead of the flight plan.

Columbia began its 36th and final full orbit at 16:18 and, two minutes later, she came into communications range of Hawaii. During this pass, Allen informed the astronauts of the impending plans to try to get data during entry with the troublesome recorder. The astronauts had been far too busy earlier to worry about it, and they sounded genuinely relieved when Allen told Young that they believed enough tape was available to "cover every S-turn you're going to make."

Before leaving contact with Hawaii, the crew pushed in the recorder's circuit breaker to start it up, and then began strapping themselves into their ejection seats. They put on their helmets and, during their final pass across the United States, conducted a good communication check through the suit loop. On completion, Joe Allen gave them a preliminary GO for the deorbit burn and told them that "*Columbia* is in super shape."

Deorbit Manoeuvre

Deorbit, the manoeuvre that would slow *Columbia* down enough to drop it out of orbit, was to be done using the two 6,000 lbf (26,700 N) Orbital Maneuvering System engines in the Orbiter's tail. As a result, the vehicle had to be manoeuvred so that these engines would be pointing into the direction of flight.

By the time *Columbia* reached Ascension Island at 16:54, the astronauts were in the process of turning to deorbit burn attitude. With all spacecraft systems looking excellent, Allen gave them a GO for the burn, which was to take place out of communications range.

As the seconds ticked off toward the crucial firing Young and Crippen checked and re-checked their ship's systems. If anything appeared abnormal, they could delay the firing. But, as had been the case throughout the flight, there were no problems. They re-verified that the Orbiter was in the proper attitude and, at exactly 17:21:30, the two engines flared to life, starting *Columbia* on its long glide to California.

During the 159.5 second burn, Crippen kept a close watch on the engine pressures while Young monitored the error needles on his Attitude Direction Indicator to ensure that *Columbia* was holding steady.

The burn went perfectly. When the engines shut down, *Columbia* had been slowed by 297.6 feet per second (90.7 mps) and was on her way back to Earth.

Four minutes after shutdown, the Orbiter came within range of the Yarragadee tracking station. The astronauts told Houston that the burn had gone well and that they had Auxiliary Power Units 2 and 3 running. The earlier temperature problems with APU 2 had caused no problems in starting up, and both it and unit 3 were looking good. The third APU was to be started five minutes before entry.

Chase Planes Take Off

Once it was known that *Columbia* was indeed on her way down, four T-38 chase planes took off from Edwards Air Force Base. Before moving out of range of Yarragadee, Allen told the crew and Young said, "Yeah, we ought to be there in about 45 minutes."

The T-38s were to fly in a five minute rectangular pattern carefully synchronised to allow them to intercept *Columbia* at about 40,000 ft (12,200 m) and stick with it all the way to touchdown. Their purpose was to provide the Shuttle pilots with additional altitude and velocity information during the final descent as well as providing photographic coverage of the landing. The four planes were actually two two-plane teams as insurance that the difficult rendezvous could be achieved by at least one of the teams.

Flying Chase-1, the plane that would call out altitudes and velocities to Young during descent, were astronauts Jon McBride and George Nelson. The backup plane was piloted by astronauts Dave Walker and Mike Mullane.

Chase-2, flown by Johnson Space Center pilot Dick Gray, with NASA photographer Pete Stanley in the back, had the job of providing live television and film of the descent. The backup was piloted by JSC Pilot Robert Walker with photographer Bobby Gray handling the cameras.

Also in the air over Edwards was one of the modified Gulfstream-2 Shuttle Training Aircraft, being flown by NASA pilots Ed Mendenhall and Charlie Hayes. Their job was to check on the weather at Edwards and make recommendations on which runway would be best to use as regards wind and visibility conditions. The weather was superb, and there appeared to be nothing against the use of lakebed runway 23, the preferred strip for this mission.

With so many aircraft in the air, the Crimson team had a second capcom, astronaut Rick Hauck, whose job it was to manage all the radio traffic between Houston and the five craft. Hopefully, this would make the rendezvous with *Columbia* easier.

ated Heading Alignment Circle. This was an imaginary 40,000 ft (12,200 m) diameter circle positioned by the computers to provide Young with a reference flight path to follow as he flew his powerless vehicle to the runway with only a given amount of velocity.

As *Columbia* intercepted the circle at 35,000 ft (10,700 m), astronauts McBride and Nelson were in position in the primary Chase 1 aircraft. Chase 2, with Dick Gray and Pete Stanley aboard, was right behind, and soon spectacular closeups of the descending Orbiter appeared on the television screens in mission control. Chase 1 pilot Jon McBride moved his aircraft beneath *Columbia* to have a look at her underside. None of the tiles were missing, and McBride told the astronauts, "You look real good underneath." From what he could see, the spacecraft seemed to be in good condition all over.

As *Columbia* came around the circle, Young maintained a 35° left bank and an airspeed of 280 knots (520 km/hr). He was finally lined up with Runway 23 as he passed 12,000 ft (3,700 m) altitude about 90 seconds from touchdown. From this point, he was able to fly straight in, using the speed brakes to maintain a 280 kt (520 km/hr) airspeed.

The craft was dropping rapidly, its steep glideslope making the descent look particularly alarming to the many onlookers at Edwards. Everything was under control, however, as the skilled hands of John Young brought the space bird in as if it were an everyday event. At 1,750 ft (533 m), just after crossing the threshold of the lake bed, Young raised *Columbia's* nose to bleed the airspeed off to 190 kt (352 km/hr) and, moments later, a scant 400 ft (122 m) off the ground, he lowered the landing gear [4].

The crowd at Edwards cheered as the gear lowered and, as Jon McBride called off altitudes to Young and Crippen, everything looked perfect. One TV reporter told his viewers, "It's incredible! It looks like Los Angeles Airport, and he's coming back from space!"

All eyes were riveted on *Columbia* as McBride called out the final few feet. "Six feet," he said, "five, four, three, two, one, touchdown!" [5]. The time was 18:20:52 GMT, 14 April 1982 as the Orbiter's two main landing gear made contact with the lake bed surface. Young lowered the nose wheel smoothly to the ground, and the vehicle began a 9,000 ft (2,700 m) rollout across the lakebed, leaving billowing clouds of dust in its wake.

"Welcome home *Columbia*," Allen said in congratulations, "beautiful, beautiful!"

"Do I have to take it up to the hangar, Joe?" Young asked in jest.

"We're going to dust it off first," Allen replied.

"This is the world's greatest flying machine, I'll tell you that," Young said enthusiastically, "it worked super!"

A minute after touchdown, *Columbia* had slowed to a stop. The glistening black and white spacecraft, looking little the worse for wear, sat majestically on the baked clay lakebed surface. The flight was over.

Post-Landing Operations

As soon as the Orbiter's wheels stopped, a recovery convoy of about 20 vehicles started speeding across the lakebed towards it. Timing was very critical, for *Columbia* was still hot after its blazing reentry of just a few minutes before. It was imperative that air conditioning units and other ground support equipment were attached within 15 minutes to prevent residual heat from soaking through the thermal tiles into the spacecraft structure and possibly damaging electronic components.

Before this could be done, technicians wearing special Self-Contained Atmosphere Protective Ensemble suits ("Scape suits") sampled the air around the Orbiter, in particular the thruster nozzles, to ensure that no toxic propellant fumes were lingering. Assured that all was safe, two large tractor-trailer rigs were backed up to the rear end. One carried a large air conditioning unit to blow cool air through the vehicle, while the other had a freon cooling system to pump liquid coolant to the Orbiter's electronics. Both were successfully connected within the required time limit.

In *Columbia's* cockpit, Young and Crippen rapidly completed the powerdown and safing of the Orbiter's many systems, and they soon were expressing an eagerness to get out. The post-landing plans called them to stay aboard for 45 minutes but as the time inched up towards one hour, Young began to get a little impatient.

"John doesn't think the passengers should have to wait this long to de-plane,". Crippen jokingly complained as the time wore on. Houston countered by reminding them that they would not have much of a wait for their luggage inside the terminal.

The Hatch Access Vehicle was soon positioned alongside the Orbiter and, before long, the hatch was opened. Various people went up and down the airline-like stairs of the unit before John Young appeared shortly before 19:24.

Wearing his ejection suit, the Commander bounded down the stairs, shook hands heartily with Flight Operations Director George Abbey, and then proceeded to inspect his ship. Young was extremely excited. There was no way for him to contain himself as he enthusiastically strutted around the Orbiter, motioning with his hands, talking about the flight to anyone who would listen.

Crippen was still inside completing a few tasks and, after several minutes, Young clambered back up the stairs – two at a time – to see what was keeping him. Both men were finally outside by 19:29, receiving the congratulations of the engineers and technicians.

The flight had gone beautifully. The sight of the white spacecraft parked on the tan-coloured desert surface, her first crew safely home, was one that few people will forget. America's return to manned space flight had been a triumphant one indeed. The flightworthiness of the Space Shuttle had been proven, and America's future in space looked secure.

Acknowledgements

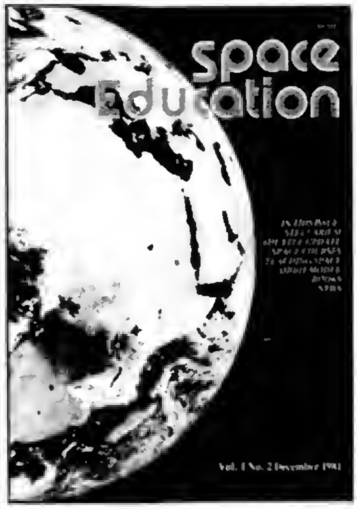
I would like to express my sincere thanks to I. L. Scott and Mike Gentry of the Johnson Space Center for providing valuable assistance and prompt replies to numerous requests for photographs and mission documents, to Andy Wilson for his encouragement, to Bruce Klind for providing video tape recordings of many mission events, and to my wife Lori, for her love and encouragement. Without her, this article would never have been written.

REFERENCES & NOTES

1. Craig Covault "First Shuttle Reentry Poses Challenges," *Aviation Week and Space Technology*, 14 May 1979, p. 38–47.
2. For a detailed explanation of the problems with the DFI PCM recorder, see Part Two of this report in the July/August 1982 issue of *Spaceflight*.
3. Ed Fendell has had much experience in the remote control of spaceborne television cameras. In 1971, he earned fame (as well as the nickname "Captain Video") for the superb job he did in controlling the television camera mounted on the Apollo 15 Lunar Roving Vehicle. Using the versatile camera, millions on Earth were able to follow the adventures of astronauts Dave Scott and Jim Irwin on the Moon, as well as getting a first-ever view of a liftoff from our celestial neighbour.
4. The Orbiter's landing gear is purposely not lowered until the very last moment in order to minimise drag. If the gear were lowered earlier, as on conventional aircraft, the Orbiter's already steep glideslope would be made even steeper.
5. As it turned out, McBride was a little early in calling touchdown. *Columbia's* wheels were kicking up dust before they actually made contact with the runway. Seeing the dust, McBride assumed the wheels had made contact, and he called it as such. Young, hearing the call in the cockpit, thought to himself, "Man, was that landing ever smooth, I didn't even feel that." Then, as Young related later, he felt a very mild jar as the Orbiter actually made contact.

PUBLICATIONS POTPOURRI

Considerable effort lies behind each issue of the Society's magazines. This article does not try to chart the progress of any particular issue, nor give a comprehensive run-down of publication procedures: rather, it gives a glimpse of some typical behind-the-scene activities. It is staggering to reflect that, on average, one magazine – containing about 50,000 words – must be completed every ten working days, regardless of other work, sickness or holidays. Each issue involves reading up to a thousand sheets of paper, writing 50 to 100 letters and many telephone calls and discussions – all before any work is done on the actual magazine itself. The office handles something like 25,000 items of mail each year – fortunately, the magazines are dispatched by our printers.



Space Education, a new BIS magazine, is proving to be tremendously popular.

A Day in the life of Spaceflight

Members receiving their copies of *Spaceflight* and *Journal* – usually around the middle of the month (apologies to members in the Antarctic – we try our best) – may not fully realise the procedures which have to be followed for this to happen.

A month may seem a long time between issues, plenty of time to get them completed one might think, but when one actually has to produce the magazine it is supersonic all the way. The magazines are produced by a total staff of two, always relieved to see an issue go out, but who are never allowed to slacken pace because new deadlines constantly appear.

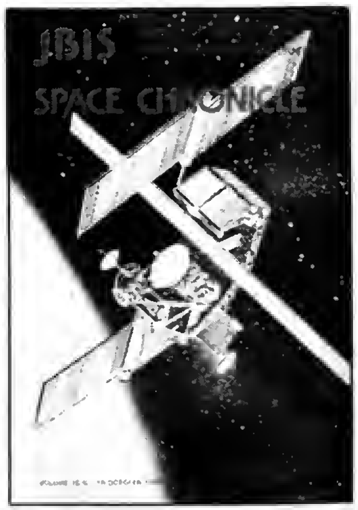
Spaceflight, with its new style of cover, continues to be as popular as ever.

Juggling Match

One big complication arises because we cannot prepare one issue at a time, i.e. finishing one and then starting another. This would be a happy state of affairs. Unfortunately, it is not that simple. Take the month of January for example, to see what's going on. Early in that month, the February issue of both magazines would have been printed off and be ready for dispatch (see later for what can go wrong at this stage). By mid-January the printers require camera-ready copy for the March *JBIS* issue and we would expect to be dealing with most of the typesetting for the April and May issues as well, and possibly some for June.

About the same time, the printers and typesetters are also knocking on the door for the final *Spaceflight* main material for setting in the April issue and expecting a complete mock layout by the end of the month. The printer's own paste-up for March also has to be ready before then. Proofs for much of the April issue will still be lying around, threatening to throw themselves in some dark corner where they will hide, undiscovered, for months.

So, at any one time, we may be juggling with 20–30 main articles and hundreds of smaller items, some of which have to go in specific issues. In between times, an author might call with a query about his article and be shocked to discover that our mental retrieval mechanism has broken down and we simply cannot recall exactly where his work is at that moment!



JBIS is divided into several types of issues: Space Chronicle, Astronautics History, Space Technology, Interstellar Studies, and others.

Gremlins

Printers, too, have their moments. It could be a machine breakdown at a vital moment or perhaps a strike or go-slow. Even paper itself is not immune. Take the June 1981 *JBIS* as an example. Some of the paper was faulty, with a line running through it. This wasn't noticed at print-out so it had to be sorted out afterwards.

Also, printing machines go broody and, apparently at random, produce odd copies with blank or missing pages.

Human error arises too. We do our utmost to ensure the right colour and the right picture the right way up, but it is not unknown for the entire cover to be re-done a second time, with the right colour and the right picture.

Where does all the material come from? We cannot simply wait for the postman to call: there is no guarantee that any material at all will arrive, still less that it will arrive in time,

be of the right standard and the right content or, indeed, be what we want!

The first step, therefore, is to identify willing authors, topics and sources of material, and keep our eyes open on space events everywhere. Typically, we could take the case of *Space Education*, where Space topics with educational aspects must be ascertained at an early stage and then developed into features or articles. This takes time and requires extensive correspondence before an author is located willing to write on a particular educational topic. If there is no alternative, we have to write them ourselves, though we often strike lucky with papers stemming from Study Courses, and Technical Symposia can put us in clover with *JBIS* for months.

Sometimes we have to compile an article rapidly in order to maintain topicality – otherwise the material may have "gone off" if left to a later issue. The large section on the Shuttle launch in the centre of the first *Space Education* was produced in three days from start to finish, including the search for suitable illustrations. We have constantly to think months ahead to what our requirements *may* be, though we can never be absolutely certain.

Every raw article has to be carefully scrutinised and made ready: items have to go before our Publications or Education Committees (or Referees) for approval or otherwise. Some odd-ball material can be dealt with right away, along with details of amazing new propulsion ideas which need just a *little* more work, a small donation, detailed calculations or finding a financial "backer".

Even when an article is accepted there is often a great deal of work to be done on it before it can be published. Each magazine has its own style so incoming material must be edited with that in mind.

We are absolutely delighted with some of the MSS – it is immaculate, of excellent quality, easy to read and has all the right-sized pictures; it requires hardly no editing and can go straight for typesetting.

At the other extreme might be a lengthy article by an author lacking a full command of English. What he is trying to say can be completely lost in translation from his own tongue. If the article is a good one, there is nothing for it but to undertake a complete re-write, obviously evening work which may take several weeks to complete.

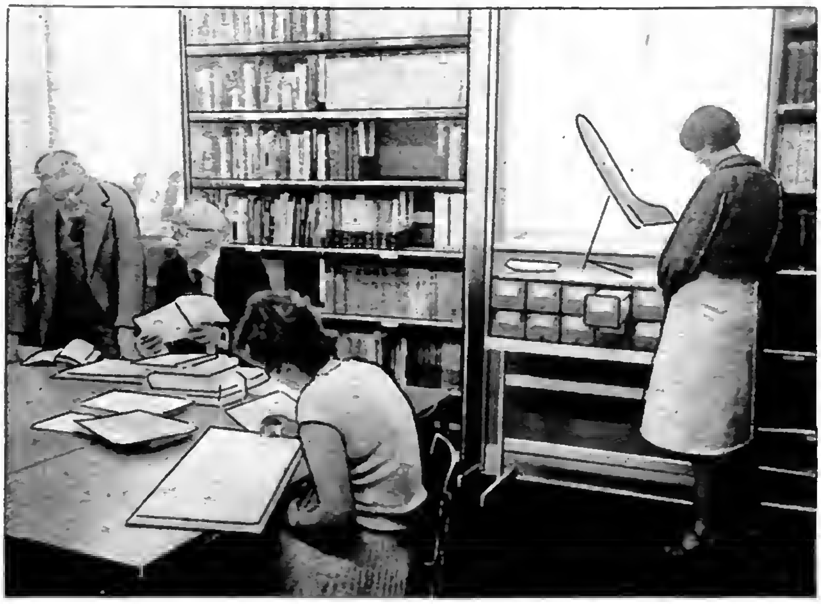
Editorial work is not restricted to spelling, punctuation and grammar or clarity of expression. The text can often be improved in other ways, e.g. by including additional material or suitable references, both of which may involve a literature search.

Right: Professor Groves, Editor of *Spaceflight*, Assistant Editor of *Space Education*, and Chairman of our Education Committee. *Below:* Len Carter, Assistant Editor of *Spaceflight* and *Space Education*, unravels a knotty problem over the telephone.

Potential Pitfalls

One also has to make sure that the article has not been or will be published elsewhere. This may happen when an author forgets to tell us that he has sent his MSS to other magazines as well. Sometimes, this can be very complicated. For example, one paper in *Spaceflight* produced an irate letter from another organisation claiming infringement of copyright. A similar paper had, in fact, been published by them, but a third similar paper had been published a year or more before in yet another magazine! Yet further enquiry brought forth the fact that even this was based on even earlier original material, which was in the public domain anyway. It was a tortuous path which caused continuing trouble, long after the paper had been printed.

We also have to compare MSS with that already published, not only because several authors sometimes claim credit for the same thing, but also to see that the same ground has not already been gone over in our own magazines.



Left: the Library is an enormous help in producing the magazines. *Above:* typesetting the Journal.

The manner of presentation can also vary enormously. We seek typewritten double-spaced "clean" copy but we don't always get it. Sometimes, the text is handwritten and, particularly when formulae are used, far from clear. If the old copper-plate style of writing was still in vogue, no doubt all would be well. As it is, we have to return practically all hand-written MSS though, in all honesty, no such MSS compared with material once submitted regularly by the late Ing. Guido v. Pirquet. His text was microscopic, half-in German: his lines of text waved up and down and, on reaching the bottom of a page, continued round the sides in various circles until the paper was fully covered and nearly every speck of whiteness buried beneath text in the ascending-descending, upside-down vogue, or even passing under or over – sometimes through other text in loops at various angles. It wasn't all continuous either. Buried were various "footnotes."

Believe it or not, we actually made sense out of some of this and published it: those must have been the days of long summers and hay-chewing.

Problems can lie in the illustrations, or lack of them. Often there are too few, and of the wrong kind. Line drawings are sent for us to redraw* or rephotograph "in our own studios." In fact, we don't and we haven't. Problems over illustrations may take months to resolve.

Sometimes we cannot publish an item of hot news, because it may be superseded by later developments by the time publication takes place. We also have to be careful about dating in another way, e.g. where MSS has to be changed from the future to the past tense – and sometimes back to the future again if all didn't go well with the launch!

A particular problem concerns the "list". Long hand-written lists on obscure topics often arrive, the writer having spent weeks compiling a list fascinating to himself but of doubtful interest to most of our readers.

There are also numerous "Why don't you ...?" letters, proposing work for other people to do. We're never too proud to use other people's ideas, but many try to saddle us with seemingly-small jobs (small to the letter-writer, that is) which would not only take hours to accomplish but which could be done only by cancelling more important work.

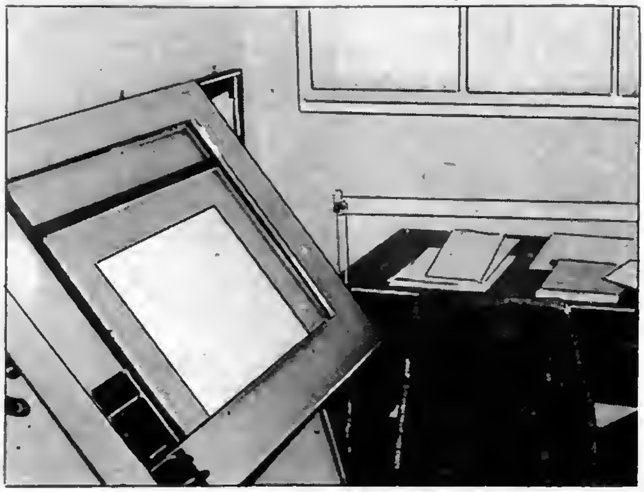
Besides considerable correspondence on solicited and non-solicited items, we have to write much material ourselves. Regular features include reports of meetings and visits, Book Notices and Society News – varying from short notes to long articles. We also face a minor hazard in getting illustrations of Society events. Volunteers armed with a camera have doubtful aim. Results are fortuitous. (We are trying to resolve this with a Polaroid so that future results can be verified on the spot.)

Proof of the Pudding

One might think that sending proofs to authors to check their papers gives the final seal of approval to the text. Unfortunately, authors may miss corrections but – worse – may decide virtually to rewrite their papers by introducing so many alterations that it really involves scrapping the original text. Typesetting corrections are troublesome, expensive and time-consuming, yet some authors try to introduce changes which involve re-setting whole sections of text.

Danger Money

Danger money is not provided for the task of "making up" magazines. This involves using a sharp surgeon's scalpel with which to slice paper – sometimes individual lines of text – to the correct size in order to complete the layout of a page, either for the printers to follow – as in the case of *Spaceflight*



Where it all happens. A small room tucked away in the farthest recesses of the BIS headquarters provides the setting for producing the Journal. Here the typeset material and illustrations are assembled on double-page sheets (seen at left) resting on a light board. The sheets are then used by the printers to produce the final pages.

– or to prepare directly in a form suitable for plate-making – as for *JBIS*.

Each page involves at least 15–20 cuts, all potentially dangerous: the scalpel just has to slip once and results can be serious. Len Carter – as an awful warning – still recites the story of how the scalpel slipped – years ago now – when he once helped with this work, with the result that he cut through to the artery in one of his fingers and was rushed off to hospital. Strangely, the story doesn't so much concern the scalpel, or indeed his bleeding finger; it dwells more on the supposed utter lack of sympathy.

Looking Heavenwards

Our own Library is now an enormous help in researching facts-and-figures for background material or for features produced entirely from HQ. Perhaps the most satisfying aspect, nowadays, is being able to suggest a topic to a willing author, providing sources and information and, above all, outlining what is wanted in the article.

Effectively, it's being an author without the drudgery of having to do the actual work!

It's the nearest we get to putting our feet up!

Keith Page often helps us out if we need something redrawn quickly. He frequently does this for us in a matter of days. Thank you, Keith!

SATELLITE DIGEST – 159

Robert D. Christy
Continued from the November issue

A monthly listing of satellite and spacecraft launches, compiled from open sources.

The headirg to each launch gives the name of the satellite or craft, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes, except where marked with an asterisk, where the time is to the precise minute as announced by the launching agency.

COSMOS 1379 1982-60A, 13281

Launched: 1100, 18 Jun 1982 from Tyuratam by F-1.
Spacecraft data: not available.
Mission: Test of Satellite Interception System using Cosmos 1375 (1982-55A) as a target.
Orbit: 540×1021 km, 100.43 min, 65.84 degrees, de-orbited same day as launch.

COSMOS 1380 1982-61A, 13282

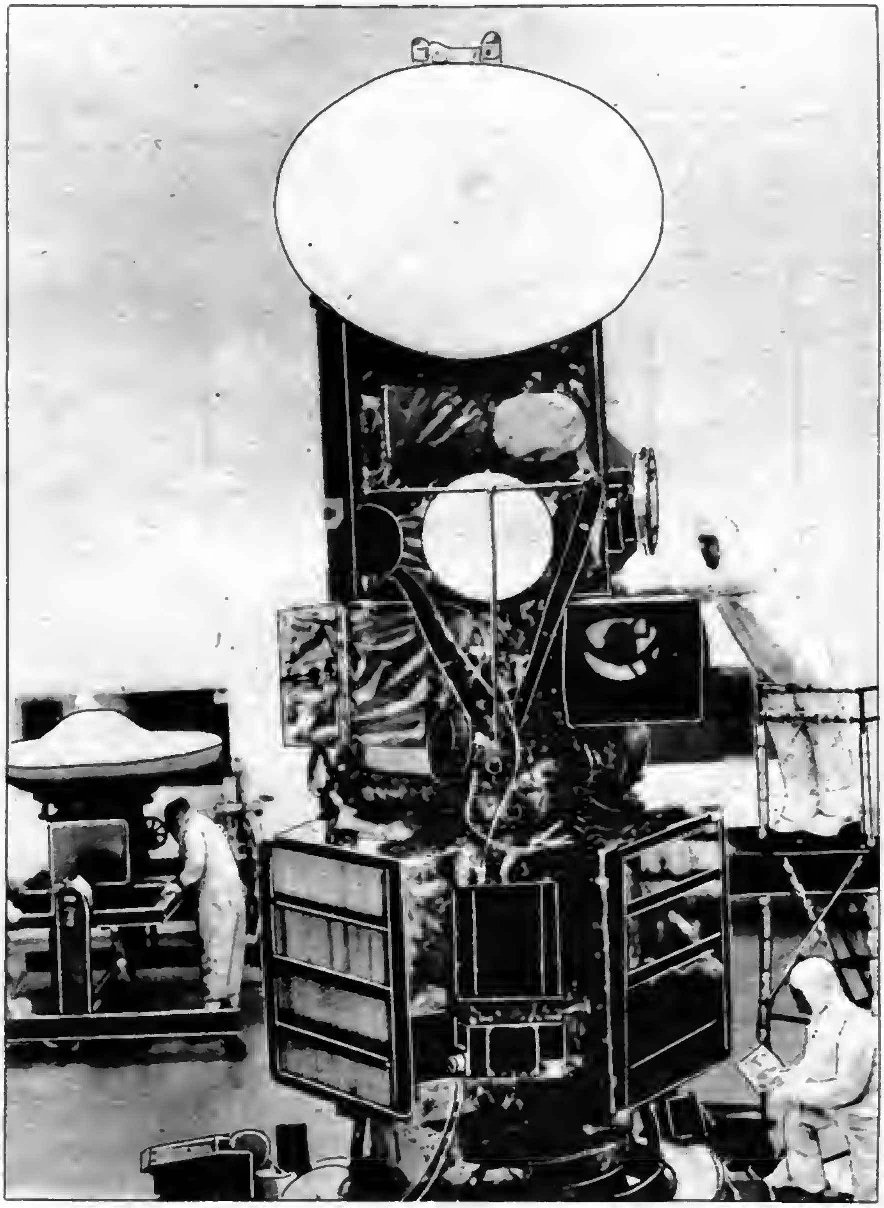
Launched: 1200, 18 Jun 1982 from Plesetsk by C-1.
Spacecraft data: Cylindrical body with domed ends, enclosed in a drum shaped solar array. Length and diameter both around 2 m, mass around 700 kg.
Mission: Navigation satellite, but early shut down of the final rocket stage prevented successful operation.
Orbit: 146×657 km, 92.63 min, 82.90 degrees instead of the intended 1000 km, 105 min orbit. The satellite decayed due to air drag after 9 days.

COSMOS 1381 1982-62A, 13283

Launched: 1300, 18 Jun 1982 from Tyuratam by A-2.
Spacecraft data: Possibly based on the Vostok manned spacecraft with spherical re-entry module, instrument unit and cylindrical, supplementary payload at the forward end. Length about 6 m, max diameter 2.4 m and mass around 6000 kg.
Mission: Military photo-reconnaissance, recovered after 13 days.
Orbit: 372×450 km, 92.71 min, 70.38 degrees.

SOYUZ-T6 1982-63A, 13292

Launched: 1630, 24 Jun 1982 from Tyuratam by A-2.
Spacecraft data: Standard Soyuz-T design consisting of a near-spherical orbital compartment, conical re-entry module and cylindrical instrument unit. Length about 7.5 m, max diameter 2.2 m and mass around 6500 kg.
Mission: Ferry vehicle carrying visiting crew of Vladimir Dzanibekhov, Alexander Ivanchenkev and Frenchman Jean Loup Chretien to Salyut 7. Docked with Salyut 7 at 1746, 25 Jun 1982, 14 minutes earlier than planned because of a computer problem. The craft and crew landed at 1421, 2 Jul 1982 after 8 days.



The Landsat 4 satellite was launched on 16 July. It carries two multispectral scanners and a thematic mapper to provide higher resolution and more comprehensive images than its predecessors for Earth resources work. See the article "Watchers in the Skies" beginning on p.338 of the Sep./Oct. issue of *Spaceflight* for a description of the satellite and its mission.

NASA

UPDATES

COSMOS 1357–1364 (1982–40A-H) orbits are 1403×1480 km, 114.71 min, 74.01 degree (lowest) and 1477×1527 km, 116.04 min, 74.02 deg (highest).

Orbit: Initially 189×233 km, 88.65 min, 51.61 degrees.

COSMOS 1382 1982-64A, 13295.

Launched: 0220, 25 Jun 1982 from Plesetsk by A-2-e.
Spacecraft data: Possibly based on the Molniya satellites, mass around 2 tonnes.
Mission: Part of the USSR's missile early warning system.
Orbit: Initially a low parking orbit and then injected into a highly elliptical one of 590×39436 km, 711.12 min, 62. 82 degrees.

STS 4 1982-65A, 13300

Launched: 1500, 27 Jun 1982 from Kennedy Space Center.
Spacecraft data: Re-usable Shuttle *Columbia*.
Mission: Fourth flight in the Shuttle's Orbital Test Programme, crewed by Ken Mattingly and Henry Hartsfield, landed after 7 days.
Orbit: 296×301 km, 90.33 min, 28.52 degrees.

COSMOS 1383 1982-66A, 13301

Launched: 2155, 29 Jun 1982 from Plesetsk by C-1.
Spacecraft data: Probably similar to the navigation satellites, see Cosmos 1380.
Mission: Test satellite for the Search and Rescue Satellite System (SARSAT), designed to pinpoint transmissions from ships and planes in distress.
Orbit: 990×1033 km, 105.36 min, 82.93 degrees.

COSMOS 1384 1982-67A, 13303

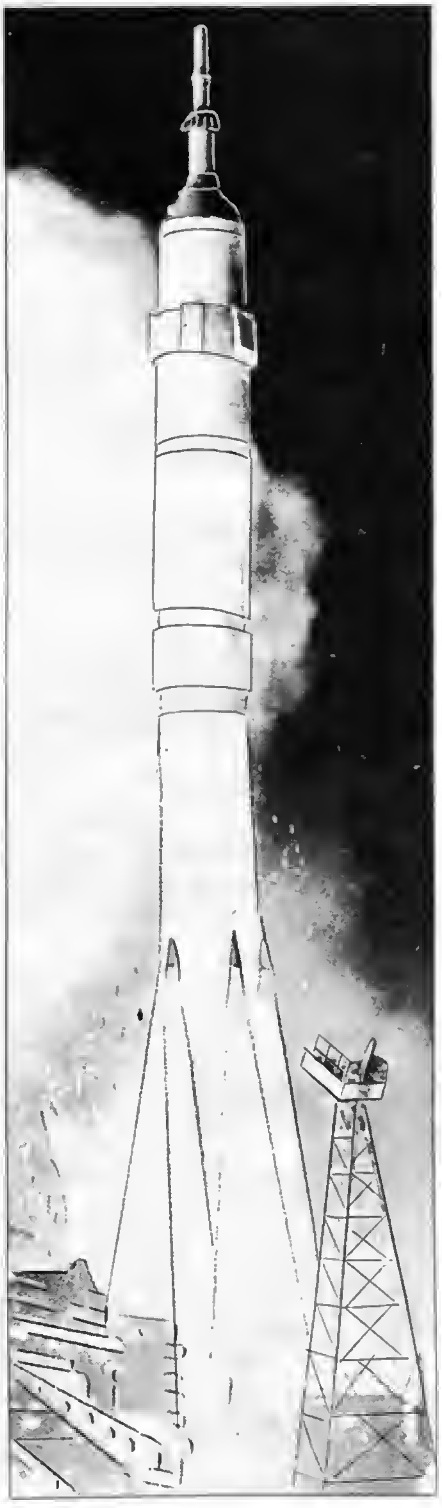
Launched: 1510, 30 Jun 1982 from Tyuratam by A-2.
Spacecraft data: Possibly as Cosmos 1381.
Mission: Military photo-reconnaissance, recovered or re-entered after one month.
Orbit: 170×354 km, 89.76 min, 67.15 degrees, manoeuvrable.

COSMOS 1385 1982-68A, 13345

Launched: 0800, 6 Jul 1982 from Plesetsk possibly by F vehicle.
Spacecraft data: As Cosmos 1381.
Mission: Photo-reconnaissance, all or part of the payload was an Earth resources package. Recovered after 14 days.
Orbit: 186×236 km, 88.75 min, 82.33 degrees.

COSMOS 1386 1982-69A, 13343

Launched: 0951, 7 Jul 1982 from Plesetsk by C-1.
Spacecraft data: as Cosmos 1380.
Mission: Navigation satellite.
Orbit: 955×1011 km, 104.78 min, 82.96 degrees.



Launch of the Soyuz T6 Mission on 24 June, carrying the first French cosmonaut, Jean Loup Chretien.

Tass

PROGRESS 14 1982-70A, 13361

Launched: 0958, 10 Jul 1982 from Tyuratam by A-2.
Spacecraft data: Similar in appearance to Soyuz-T except that the re-entry module is replaced by a cone shaped, non-recoverable compartment for stores.
Mission: To carry consumables and experimental material to the crew of Salyut 7. Progress 14 docked with the rear port of Salyut 7 at 1141, 12 Jul 1982. It undocked at 2211, 10 Aug 1982 and was de-orbited over the Pacific Ocean on 13 Jul 1982.
Orbit: Initially 192×258 km, 88.7 mins, 51.6 degrees and after docking with Salyut 7 it was 300×326 km, 90.72 min, 51.64 degrees.

COSMOS 1387 1982-71A, 13365

Launched: 0810, 13 Jul 1982 from Plesetsk, possibly by F vehicle.
Spacecraft data: As Cosmos 1381.
Mission: Photo-reconnaissance, all or part of the payload was an Earth resources package. Recovered after 13 days.
Orbit: 212×234 km, 89.08 min, 82.34 degrees.

LANDSAT 4 1982-72A, 13367

Launched: 1500, 16 Jul 1982 from Vandenberg Air Force Base.
Spacecraft data: Irregular with two solar panels, length around 6 m, diameter around 2 m and mass around 2000 Kg.
Mission: Earth resources using a variety of scanning equipment operating in different parts of the spectrum.
Orbit: 680×700 km, 98.62 min, 98.26 degrees.

1983 SUBSCRIPTION FEES

Direct Debit Scheme

As from 1 January 1983, our old Bankers Order System is being superseded by the Direct Debit Scheme. Introducing the new scheme smoothly makes it essential that all members who formerly paid by Bankers Order complete and submit their Direct Debit slip at once. Those members who have not already done so are *urged to deal with this without delay*. Duplicate Direct Debit slips are available from the Executive Secretary on request.

Amounts payable for the calendar year January-December 1983 are as follows:

RATES

Members	Sterling	US Dollars
Under the age of 18 years	£16.00	$35.00
Between 18 and 20	£18.00	$40.00
21 years of age and over	£21.00	$45.00
Associate Fellows	£23.00	$50.00
Fellows	£23.00	$50.00

Age Allowance

A deduction of £2.00 ($5.00) is allowed to members of every grade who are over the age of 65 years on 1 January 1983.

JBIS and *Space Education*

The additional subscription payable for *JBIS*, where required in addition to *Spaceflight*, is £20.00 ($44.00). For *Space Education*, it is £4.00 ($9.00).

Methods of Payment

Europe

(a) Payment should normally be made in sterling with a cheque which shows a UK address, either of the paying Bank or its Agent, where it can be presented for payment.

(b) Cheques drawn in sterling on banks in Europe (including Euro-cheques) must include £2.00 to defray bank charges and collection costs.

(c) Banks which remit directly to the Society must be instructed by members to see that the sum is transmitted *free of deductions*. (Banks frequently impose charges "in transit," so the amount actually received by the Society is insufficient to pay for the subscription thus causing much additional correspondence and trouble both to the members concerned and to the Society).

(d) Remittances from Europe can be made by GIRO: this is the easiest and cheapest method of transferring funds. Our GIRO account number is 53 330 4008.

USA and Canada

(a) Payments by US dollar cheques will be accepted if drawn on a Bank which gives an address in the United States or in the UK. US dollar cheques drawn elsewhere need to be increased by $8.00 to cover bank and collection charges.

(b) US dollar notes are accepted. Other currencies may also be accepted with prior agreement by the Society. Their value must be sufficient to include conversion costs into sterling.

(c) US or Canadian money orders can only be accepted *if expressed in Sterling*. *Internal* money orders from these countries i.e. those expressed payable in dollars will be returned as they are not cashable in the UK.

(d) Most Canadian banks have UK branches or agents: remittances may easily be made in sterling drawn on those agents. If payment is made in Canadian dollars the current exchange rate may be used, plus the addition of 8 Canadian dollars to cover exchange and collection charges.

Society Educational Tours

Halley's Comet – April 1986 – 14 days duration

Owing to the likelihood that Halley's Comet will prove to be a disappointing object when viewed from the Northern Hemisphere, if it can be seen at all, the Society plans to organise a trip to South Africa to view the comet from the Southern Hemisphere. Present indications are that the most favourable time will be the first week in April 1986.

The provisional itinerary is: flight from London to Johannesburg, four nights in Johannesburg, three day tour of Kruger National Park, flight to Port Elizabeth, three day tour of the Garden Route from Port Elizabeth to Cape Town, four nights in Cape Town, and return to London *via* Johannesburg. There will be plenty of opportunities for viewing the comet.

The approximate cost at present day prices is £1000. This includes all air and coach travel, accommodation in first class hotels, plus breakfast and dinner on coach-travelling days.

We hope to provide each participant with a copy of a Society booklet (provisionally entitled "Halley's Comet Excursion") containing a history of previous Comet apparitions, with space for observations and personal notes about the expedition itself, together with star maps and other details of the 1986 return.

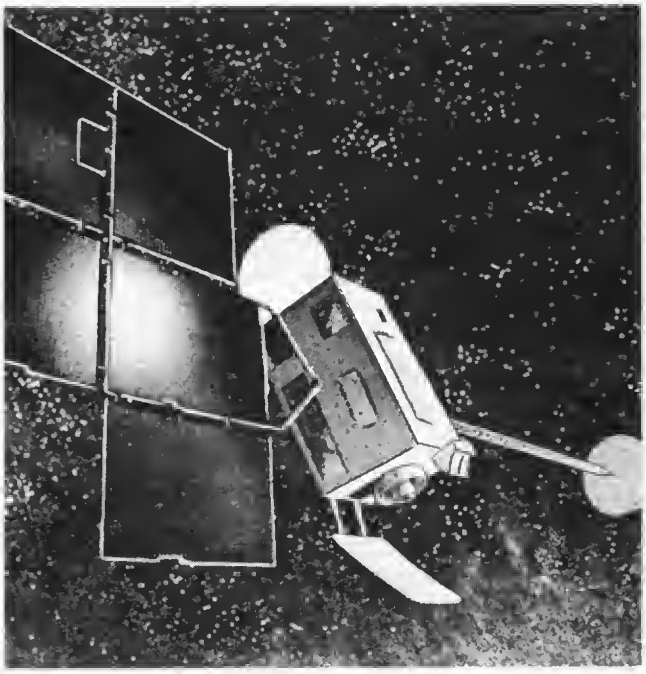
Forms for provisional registration are now available from the Executive Secretary. Please enclose a stamped addressed envelope.

A deposit of £30 per person is required, fully refundable on written cancellation at any time up to December 1985.

INSAT-1: INDIA'S DUAL SPACECRAFT

By Nicholas Steggall

By the end of 1983 India was to have two satellites in orbit to provide a domestic satellite system for communications and meteorology. Insat 1A was launched on 10 April by NASA to begin that system although, on 4 September, it had to be deactivated after unexpectedly depleting its reserves of altitude control propellant.



Insat's Objectives

Being basically two spacecraft in one, the objectives of Insat-1 are to provide:

1 High quality voice and data communications between 35 major locations within India.
2 High power video transmission for direct broadcasts to thousands of low cost television, radio and disaster warning receivers throughout India.
3 Meteorological observation of weather systems transmitted to the Meteorological Data Utilization Centre (MDUC).
4 Real time relay of data from hundreds of remote meteorological platforms to the MDUC.

The Spacecraft

Insat-1A was launched by a Delta 3910/PAM into a geosynchronous orbit located at 74°E longitude on 10 April 1982, two days later than planned. A sister spacecraft 'Insat-1B', will be taken into space by the Space Shuttle in 1983, tentatively set for the STS-8 flight with *Challenger* on 4 July. Insat-1B will use a spinning solid upper stage to place it into a similar orbit to Insat-1A at 94 deg E longitude.

The spacecraft themselves are 3 axis body stabilized with an expected seven year operational lifetime. Insat's aluminium box-like mainbody structure has dimensions of 1.55×1.40×2.18 m. Launch weight was 1,152 kg (2,534 lb) [1].

Other features are a deployable Sun-oriented solar array with 12,942 solar cells on one side of the body and a solar sail for balance on the other. An interesting feature is the bipropellant propulsion subsystem which uses monomethyl hydrazine and nitrogen tetroxide, both of which are pressurized in their tanks by helium. This subsystem provides for both the initial boost required to geostationary orbit and also for the attitude control of the spacecraft [2]. A 100 lb (445 N) thruster was used for the boost stage to apogee while six 5 lb (22 N) redundant thrusters are used for attitude control and station keeping activities.

Communications

Insat-1A used 12 transponders operating at 5935–6425 MHz (Earth to spacecraft) and 3710-4200 MHz (spacecraft to Earth) to provide communications and TV programme distribution *via* the C band and C/S band antennae. The C/S band antenna was used to transmit meteorological data, the TV downlink and half of the telecommunications downlink channels to the ground. The C band antenna was used to relay domestic telecommunications and direct broadcasting services [3]. After launch, the C band antenna did not deploy completely but after a series thruster firings and temperature-control manoeuvres, it was finally completely deployed. A series of communications experiments could then be performed by the controllers at the Master Control Facility in Hassan, India. Direct TV broadcasting to community TV sets, radio programme distribution, national TV networking and disaster warning is provided by two channels. These transponders operated at 5855-5935 MHz (Earth to spacecraft) and 2555-2635 MHz (spacecraft to Earth). Insat-1 could provide over 8000 two way long distance telephony circuits and could be tied into 35 Earth stations throughout India [4].

Meteorology

With a Very High Resolution Radiometer (VHRR) instrument, Insat can produce a full Earth picture every 30 minutes in order to provide synoptic observations of weather systems such as cyclones, sea and cloud top temperatures, snow cover, etc.

The VHRR has two channels: visible (0.55-0.75 micron) and infrared (10.5-12.5 micron) which provide resolutions of 2.75 km (1.5 mi) and 11 km (6 mi), respectively.

The meteorological system also collects and transmits meteorological, hydrological and oceanic data from unattended remote automatic data collection platforms (DCPs) and relays them to a central processing centre.

Using the TV capacity, early warning of impending climatic disasters such as cyclones and floods can reach India's population in the areas most at risk. On 3 May 1982 the first pictures taken by Insat-1A came within four hours of each other. The first was an infrared image taken at 4:00 am (local time), with the first daylight image at 8:00 am. By the time these images had been received, the satellite had been fully checked out although the solar sail had not been deployed [5].

Acknowledgements

The author would like to thank Don Flamm and D. M. Birdseye of Ford Aerospace for their help.

REFERENCES

1. *Aviation Week and Space Technology*, 5 April 1982, p.57.
2. *Flight International*, 3 April 1982.
3. *Aviation Week and Space Technology*, 19 April 1982, p.24.
4. NASA Release No. 82-44, p. 2.
5. Correspondence with D. M. Birdseye, Marketing Analyst Space Systems Operation, Ford Aerospace and Communications Corporation.

KNOW YOUR COUNCIL

An occasional series for keeping members in touch with the personalities on the Society's Council.

MARTIN FRY was born at the end of the war in London. His first encounter with rockets was as a babe in arms when a V2 landed rather too close for comfort. From this early initiation he maintained an active interest as a small boy by manufacturing a variety of projectiles from lengths of conduit and old cartridge cases.

His more formal education took place at University College School and what is now Middlesex Polytechnic where he gained an HND in Mechanical Engineering. About this time he joined Rolls Royce as a student apprentice and became totally fascinated by the aerospace world and propulsion systems in particular. During his apprenticeship he won various awards, culminating with a Robert Blackburn Open Scholarship to Cranfield. There he embarked on a two year gas turbine propulsion course and, far more importantly, marriage.

Martin Fry

His fascination for rocketry was rekindled at Cranfield by the enthusiasm of ex-Rolls Royce rocket expert Ian Smith, and the challenge of the "Rocket Competition". Martin's new wife Frankie was bullied into helping the "Hut A Team" develop a multistage rocket with the sole aim of winning a crate of Newcastle Brown for the furthest flight on the day (needless to say, November 5th). The development trials were extensive, involving the firing of Coca-Cola cans filled with special propellant and counterbalanced by a six ft stick, across the desert tracts of Bedfordshire on frosty nights. Most trials were highly successful and took place after closing time, apart from one memorable occasion when there was a near serious accident. The motor was remotely ignited using mains electricity and during one pre-flight check out in someone's room the circuit was inadvertently armed and fired. The one second delay between ignition and full power seemed an eternity to the horror-struck on-lookers. However, someone with quick reactions managed to hurl the imminent explosion through the partly closed window, at which point the rocket assumed a will of its own. It flew horizontally across the campus straight towards the kitchen window of one of the course lecturers. He looked up from his sink as the rocket bounced off the wall inches from his head and veered harmlessly towards the open country, to the great relief of all concerned.

The culmination of all this effort was the winning of the Competition with a multistage development of the simple prototype.

On a more serious note, Martin's official career at Cranfield was highly successful and culminated in the award of the Sir Roy Fedden Prize for making a "significant contribution to the fields of flight and propulsion". This he did through his MSc Thesis entitled "The Design of an Air Breathing Space Shuttle Booster Engine."

Leaving Cranfield, Martin returned to Rolls Royce and worked as a gas turbine performance engineer for four years. During this period he visited Cape Kennedy with a BIS party to see the launch of Apollo 17 – "an unforgettable experience." This cemented the resolve to eventually become a full time rocket engineer and in the mid-1970's he joined what is now British Aerospace, initially as a missile performance engineer and eventually as a propulsion specialist. A fascinating four years followed and it was with considerable regret that Martin left the industry to make a new career as a consultant specialising in Energy & Thermodynamics; "the principles are the same but there is nothing quite as mind boggling as the rate of power generation of a Saturn 5."

Martin's enthusiasm is now turned to the gargantuan task of persuading British Industry to use its energy more effectively through numerous avenues of approach. These include plant trouble shooting and monitoring, feasibility studies, energy audits and planning of site development.

Aside from work, Martin has a fascination for old vehicles and owns a 1945 James Autocycle of which only two others are known to exist. His long suffering family have recently endured a four year period during which he has rebuilt a 1934 three-wheeler Morgan which had been gently rusting in someone's shed for 20 years.

Martin and Frankie have two children and live, along with their Morgan, in Teddington.

VISITOR TO HQ

Cordial relations between the BIS and the American Astronautical Society were strengthened still further by the visit of Dr. Horace Jacobs last June.

Horace first became interested and involved in space – omitting his earlier enthusiasm for H. G. Wells and Edgar Rice Burroughs – around the time when Sputnik 1 was circling the Earth. He assisted in the editing of the first proceedings

Horace Jacobs

of the American Astronautical Society, later becoming general editor for the proceedings, and the AAS Director of Publications. Since the mid-1960's he has managed the AAS West Coast Publications Office and, since 1970 through his publishing company, Univelt, Inc., has continued editing and publishing, among other things, all AAS books. Over one hundred AAS titles have been published since 1957, most of which are in the BIS library as donations both from the American Astronautical Society and from Horace himself.

He tells us that current AAS publications of particular interest to BIS members are "Space in the 1980's and Beyond", the proceedings of the 17th European Space Symposium hosted by the BIS in London in 1980 and a new history volume called "Science Fiction and Space Futures", due out shortly.

As technical books are rather expensive, AAS editions also come in soft covers at a lower price. BIS members receive a 25 per cent discount on purchases.

STRIKING THOUGHTS

The all-too-familiar strikes by train and Underground workers may have caused some members to ponder on the theme of how, during the recent attempt to bring London to a standstill, our office still appeared to cope, apparently with undiminished energy.

A quick survey brought forth the following results. The Executive Secretary, Len Carter, travelled by car in the early morning when traffic was light, receiving the wisdom of BBC Radio 4 en route. Since this is his normal mode of travel he generally switches on to automatic for the journey and arrives with very little idea of how he actually got there. Regrettably, no thoughts of improvement enter the mind of Phil Freshwater, who also either leaves in the early hours or decamps into the night, as one prefers, for his once-a-week stint.

Sue Mandry wobbled along on her husband's bicycle, usually on the pavement and to the detriment of pedestrians and prams alike. Andy Wilson walked, his mind occupied by thoughts on a higher plane. Alan Farmer, with years of experience to draw on, darted in and out of traffic on his new bike rather like a minnow among the reeds.

Shirley Jones soldiered on, simply bashing her way through the traffic by car. Jocelyn Arthur, a short-cut fiend, vanished into long-forgotten byeways and emerged, eventually, more or less approximately near the office, by a route best forgotten.

Only Lynda Lawford travelled right royally. She arrived in style every morning, by taxi.

OBITUARIES

With regret we record the deaths of John Kirwan (Associate Fellow), a member since 1963, and Gerald Beere (Member) of Oxford.

BOOK NOTICES

The Light Stuff

R. J. Ward, Jnr., Jester Books, 295pp, 1982, $3.50.

Sub-titled "Space Humor – from Sputnik to Shuttle", this paperback is full of anecdotes and stories concerning the space business, highlighting much of the riposte which accompanied the American Space Programme and providing much insight into the attitudes of those involved. A little humour can go a long way. It, clearly, oiled the wheels considerably and did much to diffuse the many frustrations, set-backs and disappointments which must have been the lot of those involved.

Humour, of course, speaks for itself though to some extent it dims with the passage of time and when the original situation in which it was generated is long past. Even so, much of the flavour of the stories recounted is retained and still certain to raise a smile.

The collection is not one of jokes, though much of the humour is pointed. Rather more it relates to puns, pranks, wry comment and off-beat situations. To some, the irreverence portrayed might seem outrageous but it is fun nonetheless. The author has done a service in recording some of these remarks for posterity.

Contact with the Stars

R. Breuer, W. H. Freeman, 292pp, 1982, £11.95.

Subtitled "The Search for Extraterrestrial Life", this volume tackles the task from the ground floor upwards i.e. from molecule to man, ending with speculation on advanced cultures in the Galaxy, the problems of the interstellar exchange of information and, eventually, interstellar travel.

The main conclusion of the first part of the book is that, while primitive life may be quite common, technological civilizations within our Galaxy are likely to be extremely rare.

The problems of making ourselves known to other supposed civilizations, as well as identifying messages from them, form an interesting section in itself. The problem goes beyond merely making one's self known: it revolves around transmitting intelligible information starting from the need to establish a common baseline between the two supposed cultures.

It is taken for granted by most authors that contact with extraterrestrial civilizations is possible, however difficult. Few comprehend a situation where this might be impossible or, indeed, pointless. Such a case is postulated by Arthur C. Clarke in "Rendezvous with Rama" which underlines the headaches one can reach in such circumstances. Indeed, when it was pointed out to Arthur that his book had no satisfactory ending and that a sequel was clearly called for, he declined on the grounds that "a criminal should not return to the scene of the crime".

Hypotheses abound, e.g. not only is there the posed question "Where is everybody?" but also "Are we the inhabitants of a cosmic zoo" – among others.

There may be some element of doubt about the former, but surely not the latter. One has only to look around.

The Accidental Universe

P.C.W. Davies, Cambridge University Press, 139 pp, 1982, £10 H/C, £4.95 P/B.

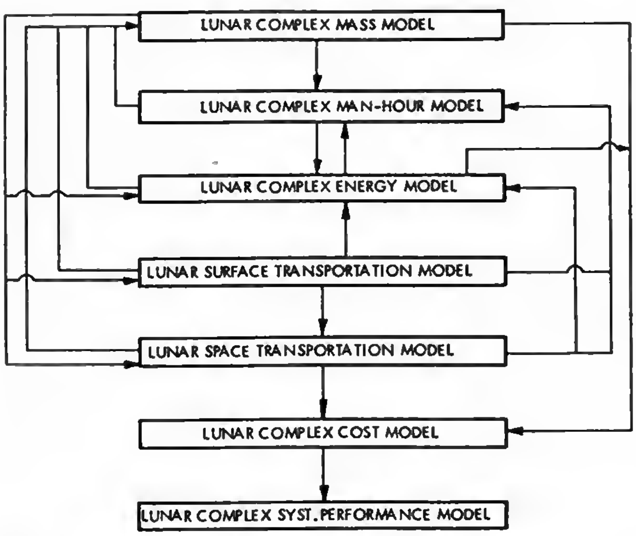
The author examines the structure and properties of the Universe and provides, for the non-specialist (but *not* non-mathematical!) reader, the provocative hypothesis that the structure of the physical world is exceedingly contrived in appearance. He surveys the range of apparently miraculous accidents of nature which have enabled the Universe to evolve its familiar structure: atoms, stars, galaxies and life itself and concludes with an examination of the so-called "anthropic principle" which postulates that miraculous coincidences are inevitable in any universe.

This thesis on a cosmic biological selection effect will both reassure and enrage readers whose very existence, in the author's words, "may be related to a piece of fine tuning in the laws of physics."

Manufacturing on the Moon

Sir, In the September issue of *Spaceflight*, a letter (p. 381) from Ben Bova suggests the use of an aluminium/oxygen rocket as a means of reducing the cost of lunar operations, presumably for the task of lifting material off the Moon's surface. This was one of the systems looked at by General Dynamics/Convair in a paper presented at the 1978 AIAA Propulsion Meeting in Las Vegas as an alternative to O'Neill's "mass driver" for exporting material from the Moon. It looks attractive at first: the materials are all indigenous and the mass of plant you need to set up on the Moon is certainly far less than that for an operating "mass driver". The economics, however, depend on the attainable specific impulse, and here there is a problem.

The principal product of combustion of aluminium and oxygen (Al_2O_3) is a solid or liquid at the temperatures encountered in rocket engines. While the energy release is large, to convert that thermal energy into kinetic energy (and hence generate useful thrust) you have to use it to heat up a gas. Hydrogen would be the best, but in the absence of that theoretically you could use oxygen. It might be difficult to protect the engine structure from an exhaust of very high temperature oxygen, but the "loss-free" specific impulse works out to about 3,300 m/s. However, it is not loss-free. The alumina in the exhaust contributes a very large "two phase flow loss"; it has to be accelerated along with the gas, and it retains most of the heat. Typically you might loose 20–25 per cent of the specific impulse this way, and at these values the aluminium/oxygen engine ceases to look economic.



Lunar base model structure as used in "Manufacturing on the Moon" (*Spaceflight*, April 1982, p.147).

In fact, you don't have to import very much hydrogen to operate a lox/hydrogen rocket: over 85 per cent of the propellant is liquid oxygen. There are various "break even" points which are of interest. The easiest is when it requires less material delivered into Earth orbit to transport material from the Moon's surface into lunar orbit than to deliver the same material from Earth orbit. The most difficult is when it becomes easier to deliver material into a *low Earth* orbit from the Moon. Taking the first of these, with chemical propulsion you have to assemble 4·6 tonnes of material in Earth orbit for each tonne in lunar orbit. To deliver the same tonne from the Moon you need only 0·19 tonnes of liquid hydrogen there, or about 2 tonnes in Earth orbit. So lox/hydrogen propulsion already meets the first break-even condition.

You can do even better than this. Lox/hydrogen rockets are operated at a 15 per cent hydrogen level to get the best specific impulse, but at 11 per cent hydrogen you loose only 4 per cent on specific impulse. To deliver 1 tonne into lunar orbit now only requires 1·8 tonnes in Earth orbit.

Delivery into an Earth-centred orbit really only requires achievement of slightly more than lunar escape velocity if we could use aerobraking at Earth approach. It occurs to me that to build a full-scale electromagnetic accelerator capable of achieving lunar escape might well be difficult and costly, but a smaller accelerator designed for only a few hundred metres per second would allow small rockets to achieve lunar orbital velocity with a significant reduction in propellant requirements. If these were to act as "tankers" supplying low cost liquid oxygen in lunar orbit, we might even attack the most difficult "break even" condition: delivery into a low Earth orbit. There is obviously scope for further analysis along these lines. The conclusion, however, remains: a *liquid oxygen plant on the Moon is like having your own oil well* there.

R.C. PARKINSON
Propellants, Explosives and Rocket
Motor Establishment (Waltham Abbey)

Global Space Agency

Sir, In recent months there has been some discussion in *Spaceflight* about the formation of a global space agency [1–3].

Readers may be interested to know that Pakistan proposed the formation of such an international space agency at the recent United Nations' Unispace conference in Vienna. Sadly, the proposal has as yet received little support from the leading space nations, but it is encouraging to see the subject raised at this level.

IAN CRAWFORD
Warrington, Cheshire

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1. *Spaceflight*, p. 316, November 1981.
2. Correspondence, *Spaceflight*, p. 91, February 1982.
3. *Spaceflight*, p. 268, June 1982.
4. *New Scientist*, p. 472, 19 August 1982.

The First Cosmonaut

Sir, In a Novosti Press booklet "In Gagarin's Trail" (1980) there are some interesting references to the selection of the first cosmonaut:

"'We, the first cosmonauts, met Korolyov at a research institute in October,' cosmonaut Alexei Leonov recalls. 'Korolyov had gathered a good deal of objective information about each of us, including the results of flying practice, parachute jumps, and the study of equipment. For some reason he called out the names of people in alphabetic order. Somewhere in the middle of the conversation Gagarin's name was mentioned. Yuri stood up and I noticed that Korolyov began to scrutinise him more closely than others . . .'

"The State Commission had a meeting on the eve of the launching and the floor was given to the head of the cosmo-

naut's team, General Nikolai Kamanin. Evidently, the outstanding pilot had reflected a great deal before saying 'I suggest that Senior Lieutenant Gagarin be assigned the flight with Gherman Titov as standby.'

"Korolyov seconded General Kaminin's motion. 'Observing Gagarin,' he said, 'I find in him an analytical mind and rare industriousness. We need profound information about outer space and I have no doubt that Gagarin will bring it.'

"The vote for Gagarin was unanimous.

"Many years after Gagarin's flight, General Kaminin would say, 'I often hear people wondering who appointed Gagarin the Number One cosmonaut: Korolyov, Kaminin or somebody else? In reply to this, I say that it was Gagarin who appointed himself, as it were. He had firmly made up his mind to be the first to fly.'"

GERALD BORROWMAN
Canada

Summer 1938. L. to R.: Ross, Edwards, Turner, Truax, Smith, Hanson and Clarke.

Gagarin Theory

Sir, I have come to the opinion that, considering Yuri Gagarin's high position in the cosmonaut corps, that the Soviet Government would have assigned him to another spectacular space mission to obtain maximum propaganda value.

And it is for that reason I suspect that, on 27 March 1968 when he died in an air crash, he was in training for a mission which was to be launched in the autumn of 1968, as the lone occupant of a manned Zond spacecraft.

It is only logical that, when Gagarin died, his backup would have received the assignment, which leads me to think that cosmonaut Belyayev was backup for this six day circumlunar mission.

In James Oberg's "Red Star in Orbit" there is a photograph of Gagarin and other cosmonauts looking at Luna photographs of the Moon. I suspect it is no coincidence that it is Gagarin holding the photographs with someone who looks like Belyayev next to him.

ARTHUR STURTS
Wartington, USA

Philip Clark replies:

Mr. Sturts' idea is interesting, but can be no more. Cosmonaut Sevastyanov has said that he was the training manager for a group of cosmonauts who were working in the Black Sea area in preparation for manned Zond missions. As well as Sevastyanov, the full group was: Leonov, Bykovski, Popovich, Dobrovolsky, Klimuk, Artyukhin, Grechko, Makarov and Rukavishnikov. Therefore, we must rule Gagarin out for a Zond mission. It is known that Gagarin was the Soyuz 1 back-up commander, and therefore he would have been a logical choice for the replacement mission carried out by the Soyuz 4/Soyuz 5 mission, possibly as the Soyuz 4 commander.

BIS History

The well-known 1938 BIS photograph showing Ross, Edwards, Turner, Truax, Smith, Hanson and Clarke (reproduced here) has always aroused considerable interest among space historians. Maurice Hanson (second from right) was not one of the better-known faces among the group but the letter below does throw some light on his fate.

Sir, Maurice Hanson was a schoolfriend of mine who formed Chapter 22 of the Gernsback-sponsored Science Fiction League about 1935 while still at school. Although I never met him after he left school and went to live in London we kept in touch by letter for the rest of his life. He was a rather solitary type of person, and when he died in lodgings in London last year his landlady found this photograph amongst his effects, together with letters from me, and sent it to me thinking that I might be the Smith in the picture.

I was myself an early member of the BIS, but have never taken an active part. The nearest I got was in offering my talents as an engineering draughtsman to a technical group formed in the late 1930's, but when I received a peremptory request one morning to attend a meeting in London a few minutes after I returned from work in Coventry that evening I took it to mean that I was not needed, and gratefully sunk into inertia!

D.R. SMITH
Coventry

Stamp of Authority

Sir, Under "Philatelic News" (p. 374 of the September/October issue) you rightly presented a good case for UK Space stamps in 1983 (or one stamp at least). I imagine the Post Office get many similar requests, the great majority of which are obviously rejected.

Being a philatelist, I get just as fed up with some of the obscure themes and anniversaries that are chosen. Truly, the mind boggles!

You mention three of the themes chosen for 1983, saying they do not appear to mark any anniversary. However, they do, and here they are. I leave it to you to decide just how relevant they are, or how much public interest they have:

"Gardens": 200th anniversory of death of Lancelot Brown (otherwise known as "Capability Brown").
"River Fish": 300th anniversary of death of Izaak Walton ("The Compleat Angler").
"British Fairs": 850th anniversary of the St. Bartholomew's Fair, Smithfield, London.

Never mind, perhaps the BIS will be recognised in the stamps for 2033!

The Editor is always interested in receiving items of correspondence, notes, comments, or reviews for possible publication. Items submitted must be kept brief, owing to the limitations of space in our magazine. The Editor reserves the right to shorten otherwise adapt material to fit, for this reason.

SPACEFLIGHT

Volume XXIV
1982

Editor: G.V. GROVES, Ph.D., F.B.I.S.

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List of Contents

MAIN ARTICLES

Adelman, S.J.	Terraforming Venus	50
Beck, R. and Koppmann, R.	Saturn's "Spokes"	85
Borrowman, G.L.	Recent Trends in Orbital Reconnaissance	10
"	Training for Space	129
"	The Military Role in the Shuttle	226
"	Safety Aboard the Space Shuttle	249
Christy, R.D.	Satellite Digest	32,80,136,185,230,282,327,370,417,469
Davies, J.K.	A Brief History of the Voyager Project: Pt. 5	67
"	A Brief History of the Voyager Project: Pt. 6	253
"	Space Telescope: Eye on the Universe	434
Day, L.E.	Preliminary Results from STS-3	310
Gatland, K.W.	Prelude to the Space Age	386
Gire, B.	The Ariane Launcher	358
Griffith, J.S.	Astronomical Notebook	82,278
Harris, G.L.	News from the Cape	23,71,112,225,270,305,365,414
Harris, R.	Watchers in the Skies	338
Hendrie, M.J.	The Return of Halley's Comet	242
Hooper, G.R.	The Cosmonauts - 22	30
"	The Cosmonauts - 23	163
Hurst, S.K.	Towards an International Space Cooperation Agency	268
Johnson, N.L.	The Crowded Sky	446
Kidger, N.	Salyut 6 Mission Report: Pt. 9	28
"	Salyut 6 Mission Report: Pt. 10	74
"	Salyut 6 Mission Report: Pt. 11	174
"	India's SLV-3 Launch Vehicle	72
"	Hipparcos: Europe's Astrometric Satellite	165
"	Japanese Space Plans for 1982-1985	202
Koelle, D.E.	Reusable Space Platforms	119
Koelle, H.H.	Manufacturing on the Moon?	147
Loyd, O.H. and O'Brien, K.J.	The Medical and Public Health Challenge of Space	205
Maley, P.D.	Percheron - A Space Workhorse	133
McLaughlin, W.I.	Travellers' Tales	114
"	Space at JPL	342,393,442
Mutschlechner, M.	Spacelab, Space Sickness and the Space SLED	218
Parkinson, R.C.	Prospects for Interplanetary Exporation	98
Peebles, C.	Satellite Photograph Interpretation	161
"	The U.S. Air Force Test Pilot School	167
"	The Manned Orbiting Laboratory: Pt. 3	274
"	The Original Voyager	302
Pfannerstill, J.A.	Shuttle to the Rescue!	54
"	The Maiden Voyage of "Columbia": Pt. 1	194
"	The Maiden Voyage of "Columbia": Pt. 2	295
"	The Maiden Voyage of "Columbia": Pt. 3	460
Shayler, D.J.	John Young - One Man's Conquest of Space: Pt. 1	221
Sheaffer, r.	The Decline and Fall of SETI	457
Shelton, R.M.	Transportation for Solar Power Satellites	2
Simpson, C.	The French Space Budget and Programmes (1982)	415
Steggall, N.	The NOAA Environmental Satellites	34
"	Japan's Geostationary Meteorological Satellite System	283
"	INSAT: India's Dual Spacecraft	472
Thomson, A.A.	Off to the Asteroids	7
"	Exploring Mars with "Kepler"	151
"	DISCO - Europe's Solar Astronomical Satellite	266
Wilson, A.	The Solar Mesosphere Explorer	24
Wilson, K.T.	The Recovery of American Manned Spacecraft 1961-1975	179

FEATURES

Book Reviews 41,93,142,287,419,474
British Interplanetary Society
36th Annual General Meeting 188
37th Annual General Meeting 330
Society Meetings 39,88,140,187,235,286,376,425
Society News 36,86,190,232,285,328,373,422,473

Correspondence 44,91,143,191,239,288,334,381,427,475

MLR: A Shuttle Experiment 396

Probing the Giant Planet 290
Publications Potpourri 466

Report of the Council 332

Space Communications - *See Space Report Index*
Space Report - *See Separate Index*
Spacelab 2 and 3 Missions 20
STS-2: A Mission Almost Accomplished 103

Welcome to Rome 56

SPACE REPORT

Ariane 225,259,352,402,403
Asteroids 343
Astrology 456
Astronauts 210,213,215,259,264,351,354,456

Batteries 459

Canada 407
China 65
Columbia 398
Comets 125
Computers 125
Cosmology 125

Delta 64,454
DOD Astronauts 456

ESA
Astronauts 19,213,259
DISCO 407
Japan Cooperation 126
Magellan 454
Microgravity 355
Remote Sensing 353

Galileo 14,393,402
Gamma Ray Astronomy 395
Geodesy 17
Gravity Probe 64

India 215,355
Indonesian Communications 217
Infrared Astronomy 408
Infrared Telescope 208
INMARSAT 272,398
IUS 154,308

Jet Propulsion Laboratory 342,393

Laser Dockings 127
Lightning 455

Maritime Communications 27,128,171,272

Mars 157,263,317,354
Meteorites 320
Microgravity 214,355
NASA
1982 Launch Schedule 159
Antennae Closed 65
Associate Administrator 18
Budget 71,270
Centres Merge 19
Faget Retires 124
Goddard Director 356
Kleinknecht Retires 127
Kraft Retires 350
Major 1981 Events 159
New Launcher? 155,402
OPEN 210
Slayton Retires 263
UARS 210
Visitor Center 127

Orbit Transfer Vehicle 214
Orbiting Telescopes 261

Pioneer 16,323,354
Planetary Image Facility 395
Planetary Missions 343
Propulsion Module 124
Pulsars 308

Radar 15
Radio Amplifier 301
Radio Astronomy 407
Reusable Launchers 209
Rhythm Research 456

Satellite Earth Station 26,273,347
Satellites
AMPTE 62,124
Anik C2, D 27,345,398
Ariel 6 262
ATS 172,208
Aussat 173,345
Direct Broadcast 27,173,217,300,400

Dynamic Explorers ... 15,308
ECS ... 79
Exosat ... 264
Fltsatcom ... 345
Gamma 1 ... 66
GRO ... 215
Gstar ... 26,128
HEAO ... 158,321
Himawari 2 ... 16
Hipparcos ... 19
Insat 1 ... 30
Intelsat ... 27,171,345,347
IRAS ... 15,342
IUE ... 19
Japanese ... 300
Leasat ... 346
L-Sat ... 128,171
Milstar ... 347
Navstar ... 79
NOVA ... 452
Oscar ... 79
OTS ... 128
Reconnaissance ... 410
Remote Sensing ... 353
ROSAT ... 455
Satcom ... 128,216
SBS ... 26
SCATHA ... 355
SMM ... 64,410
Solar Observatory ... 271
Syncart ... 79
TDRSS ... 124
Teal Ruby ... 408
Tiros N ... 357
Westar 4 ... 273
X-ray ... 214,348
Saturn ... 261
Scramjets ... 155
Search and Rescue ... 459
Shuttle
Challenger ... 406
Conference ... 348
Contractors ... 307
Controls ... 405
Costs ... 307
Crews ... 324
External Tank ... 64,225,356
Facilities ... 225,271
Fifth Orbiter ... 264,305,366
Insulation ... 356
Landing System ... 407
Launch Schedule ... 355
Liquid Hydrogen ... 412
Management Changes ... 350
Materials Processing ... 260,367
Military ... 366
Ozone Problem ... 307
Payload Pricing ... 225,405
Programme ... 112,365
SRB ... 308,350,355,412
Storm Experiment ... 414
STS-2 ... 156,225,307,344
STS-3 ... 64,157,211,265,324
STS-4 ... 306,351,412,414
STS-5 ... 264,351,450
Suit Display ... 404
Tethered Satellites ... 320
Tiles ... 326
Tracking ... 400
Turnaround ... 23
Skylab ... 15
Solar Power Satellites ... 63
Solar Sails ... 62
Solar Telescope ... 19
Sounding Rockets ... 14,17,157,348
Soviet
CETI ... 356
Komarov Memorial ... 403
"Medusa" ... 214
Salyut 6 ... 214
Salyut 7 ... 126
Venera 13/14 ... 318
Venus/Halley Mission ... 210,321
Space Award ... 301
Space Communications ... 26,79,128,171,216,272,300,345,398
Space Pioneers ... 160
Space Station ... 65,308,366,402
Space Survey ... 160
Space Telescope ... 66,154,265,319,323
Spacelab ... 66,154,208,210,211,407,453
Stellar Ejection ... 357

Telesat Agreement ... 459
Tenth Planet ... 405
TDMA ... 347
Torus Antenna ... 398
Total Eclipse ... 17
Transatlantic Communications ... 217
Trees ... 215

UK Space Symposium ... 409
UK Telescope ... 159
Uranus ... 403

V2 ... 326
Venus ... 210,259,318,321,350
Viking ... 317,354,395
Volcanic Cloud ... 319,411
Voyager ... 62

"Weather Reporter" ... 408

NOTICES OF MEETINGS

ASTRONOMICAL STUDY COURSE

During its 50th Anniversary Year, the Society will embark on its most ambitious Study Course yet. Called "Update your Astronomy", the Course, organised in collaboration with Astronomers at the Royal Greenwich Observatory, will provide an opportunity for members to learn of the many new and exciting developments in astronomy in recent years.

Because of the number of lectures, the course will extend over two sessions with a reduced fee (£10) where Registration is made for the combined course at the same time. The fee for each of the two sessions is £6, if paid singly. Registration Forms are available from the Executive Secretary.

The topics and the speakers are listed in the Notices below as fully as space permits, in chronological order: 24 November, 1 December, 5 January 1983, 2 February 1983, 2 March 1983, 30 March 1983, 6 April 1983, 14 April 1983.

Film show

Theme: **STEPS TO THE MOON – 3**

The third programme in this series will be screened at a meeting to be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **17 November 1982**, 7.00-8.30 p.m.

The programme will include the following:

(a) Apollo 11 — Eagle Has Landed
(b) Apollo 12 — Pinpoint for Science
(c) Apollo 13 — Houston, We've Got a Problem!
(d) Apollo 14 — Mission to Fra Mauro
(e) Apollo 15 — The Mountains of the Moon

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Study Course

Title: **THE EARLY UNIVERSE**
by Dr. J. D. Barrow
University of Sussex

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **24 November 1982**, 7.00-9.00 p.m.

For details on joining the "Update Your Astronomy" Study Course, see the note at the beginning of these Notices. Since all of our speakers are working astronomers, it may be necessary occasionally to change the sequence of lectures.

Study Course

Title: **OBSERVATIONAL COSMOLOGY**
by Dr. J. Wall
Royal Greenwich Observatory

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **1 December 1982**, 7.00-9.00 p.m.

For details on joining the "Update Your Astronomy" Study Course, see the note at the beginning of these Notices. Since all of our speakers are working astronomers, it may be necessary occasionally to change the sequence of lectures.

Film Show

Theme: **STEPS TO THE MOON – 4**

The fourth meeting in this series will be screened at a meeting to be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **8 December 1982**, 7.00-8.30 p.m.

The programme will include the following:

(a) Apollo 16 — Nothing So Hidden
(b) Apollo 17 — On the Shoulders of Giants
(c) The World Was There
(d) The Time of the Apollo

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Study Course

Title: **UPDATING QUASARS**
by Dr. K. Hartley
Royal Greenwich Observatory

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **5 January 1983**, 7.00-9.00 p.m.

For details on joining the "Update Your Astronomy" Study Course, see the note at the beginning of these Notices. Since all of our speakers are working astronomers, it may be necessary occasionally to change the sequence of lectures.

Lecture

Title: **SPACE COMMUNICATIONS PROGRAMMES IN EUROPE**
by Dr. R. Collette
ESTEC

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **26 January 1983**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Study Course

Title: **THE INTERSTELLAR MEDIUM**
by Dr. M. Pettini
Royal Greenwich Observatory

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **2 February 1983**, 7.00-9.00 p.m.

For details on joining the "Update Your Astronomy" Study Course, see the note at the beginning of these Notices. Since all of our speakers are working astronomers, it may be necessary occasionally to change the sequence of lectures.

Lecture:

Title: **SPACE LAW TODAY**
by C. E. S. Horsford

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **16 February 1983**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Study Course

Theme: **UPDATE YOUR ASTRONOMY**

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **2 March 1983**, 7.00-8.30 p.m., with a showing of films on the above topic.

For details on joining the "Update Your Astronomy" Study Course, see the note at the beginning of these Notices. Since all of our speakers are working astronomers, it may be necessary occasionally to change the sequence of lectures.

Lecture

Title: **SPACE OCEANOGRAPHY**
by Dr. J. O. Thomas
Imperial College, London

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **16 March 1983**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Continued on back cover

SPACEFLIGHT

Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 27/29 South Lambeth Road, London SW8 1SZ Tel: 01-735 3160

Correspondence and manuscripts intended for publication should be addressed to the Editor, 27/29 South Lambeth Road, London SW8 1SZ.

Opinions in signed articles are those of contributors and do not necessarily reflect the views of the Editor or the Council of the British Interplanetary Society, unless such is expressly stated to be the case.

Continued from inside back cover

Study Course

Title: **CATACLYSMIC VARIABLES**
by Dr. D. Jones
Royal Greenwich Observatory

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **30 March 1983**, 7.00-9.00 p.m.

For details on joining the "Update Your Astronomy" Study Course, see the note at the beginning of these Notices. Since all of our speakers are working astronomers, it may be necessary occasionally to change the sequence of lectures.

Study Course

Title: **THE NEW LA PALMA OBSERVATORY**
by Dr. P. J. Andrews
Royal Greenwich Observatory

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **6 April 1983**, 7.00-9.00 p.m.

For details on joining the "Update Your Astronomy" Study Course, see the note at the beginning of these Notices. Since all of our speakers are working astronomers, it may be necessary occasionally to change the sequence of lectures.

Technical Forum

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ on **Friday, 3 June 1983**, 6.30-9.00 p.m., and **Saturday, 4 June 1983**, 10.00 a.m. to 12 noon and 1.30-3.30 p.m.

Topic: **THE SOVIET SPACE PROGRAMME**

It is anticipated that papers will be given at the Friday evening and Saturday afternoon sessions, with some Soviet space films being shown during the Saturday morning session.

Offers of papers are invited. Further information may be obtained from the Executive Secretary of the Society. Members with a special interest in the Soviet space programme are invited to attend. A registration fee of £3.00 is payable. Forms are available from the Executive Secretary on request, enclosing a stamped addressed envelope.

18th European Space Symposium

Theme: **FUTURE SPACE PROGRAMMES FOR EUROPE**

To be held in the Society's Conference Room at 27/29 South Lambeth Road, London, SW8 1SZ on **8–10 June 1983**. Organised by the BIS and co-sponsored by the DGLR, AAAS, AIDAA and AAS, with support from Eurospace. The number of participants will be limited to a maximum of 60, with priority to Speakers, Society Representatives and subject specialists.

Offers of papers are invited. Further information may be obtained from the Executive Secretary of the Society.

Programmes and Registration forms will be available in due course.

1983 TOTAL SOLAR ECLIPSE

Since the 1981 Eclipse Expedition was so successful, the Society is interested in sponsoring a further trip to see the total eclipse of the Sun from Java on 11 June 1983. This will be the longest total eclipse in a decade. The tour will last for 21 days and include full air fare, hotels, meals and other transportation.

Included will be stopovers at Hong Kong, Bangkok, the Isle of Penang, Kuala Lumpur, Singapore and Bali – all sites of astronomical, archeological, historic, artistic and, undoubtedly, photographic interest.

For further information, write direct to:

R.V. Frampton, MS 264-519, Jet Propulsion Laboratory, Pasadena, CA 91109, USA.

LIBRARY

The Library will be open to members from 5.30-7.00 p.m. on each of the following dates:

17 Nov. 1982	24 Nov. 1982
1 Dec. 1982	8 Dec. 1982
5 Jan. 1983	2 Jan. 1983

While every effort will be made to adhere to the published programme, the Society cannot be held responsible for any changes made necessary for reasons outside its control.

GIFTS AND DONATIONS TO THE SOCIETY

Most established Learned bodies in the UK owe their prestige and affluence to Endowments and Gifts conferred in the past. These have enabled them to perform tasks, expand, build up valuable libraries and collections of paintings, seek prestige premises and undertake a multitude of projects which, cumulatively, established them in the shape of the major organisations they are today.

Our own Society, eventually, may benefit in a similar way but it is important that we start by bringing to the notice of our members, particularly our long-standing members, this important way of contributing to the Society's work.

Several members lately, and their spouses, have already recognised this as a most acceptable way of making a contribution to the Society in a manner which they found very satisfactory. We hope that many more will do so.

Members who might like to consider donating to the Society, eventually, some gift of books, paintings, money, etc. by making provision for it in their Wills are invited to discuss it, first of all, with the Executive Secretary, who can supply some explanatory notes on the procedure to be adopted if necessary.

Gifts like this do not require making out a new will. An existing will can easily be altered to include the gift, simply by making out a Codicil. The Executive Secretary will explain this, too, if required.

So many ways are open to make useful gifts which will materially enhance our Society. If you are interested and would like to discuss your ideas or seek advice please do write to The Executive Secretary indicating, in general terms, what you have in mind and would find most satisfactory.

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